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PERCIVAL LOWELL.

The following account of the life of Percival Lowell was issued from the Lowell Observatory in January 1917. It is an admirable account of a man of genius, who was able to put into popular form the conclusions to which his investigations led him and who has added perhaps more than any other man to our knowledge of the conditions existing on the surfaces of other planets than our own.

The sudden death of Percival Lowell, at his observatory at Flagstaff, Arizona, deprives the world of one of the very few men whose inclination and ability enabled them to devote their lives and their resources to the advancement of pure science. Few there are who have not heard of his fame and been enlightened by the results of his labors; he believed in making free to all, by voice and pen, those wonderfully illuminating discoveries in regard to other worlds, those mathematical unravelings of the tangled skein of planetary perturbations by which he read the secrets of the universe.

Percival Lowell was a member of a brilliant family, well known in the history of New England. He was born in Boston, Massachusetts, on March 13, 1855. His father, Augustus Lowell, was closely identified with the education, art and science of Boston. His mother, Katharine Bigelow Lawrence, was the daughter of Abbott Lawrence, United States minister to Great Britain in 1851. The cities of Lawrence and Lowell attest that both families were prominent founders of the textile manufactures of New England.

Dr. Lowell prepared for college at "Noble's" School and graduated from Harvard in 1876. He was given the degree *cum laude*, and received second-year honors in mathematics. But the true distinction of his later career was foreshadowed by a remark of the elder Pierce, the mathematician of his day, who spoke of him as one of the most brilliant mathematicians of those who had come under his observation at Harvard.

After a year spent in travel in Europe and the East, Lowell returned to Boston. He became a force in the business world, where at various times he held the offices of treasurer of cotton mills and director of trust and electric companies. He was one of the few men who combined scientific abilities of the first order with a marked instinct and gift for matters of finance. And when he later embraced the career of a man of science, he never abandoned his hold on the world of affairs.

From 1883 to 1893 his energies were chiefly devoted to literature and travel. In the spring of 1883 he settled in Tokio, where he was appointed counsellor and foreign secretary to the Special Mission from Korea, then on its way to the United States. This resulted in his return to this country in charge of the travels of the party through America. It was the first embassy ever sent by Korea to a Western Power. On the return of the mission to Korea, he remained in the country for a time as the guest of the government. An account of his travels there he published under the title, "Choson—The Land of the Morning Calm." The volume is full of imagination and charm and gives evidence of a light touch and a true literary gift.

Until 1893 much of his time was spent in the Far East, chiefly in Japan. In 1888 he published his "Soul of the Far East," which Janet, the French psychologist, has characterized as a valuable contribution to the psychology of the Orient, and as showing a remarkable insight into the Eastern mind. "Noto," a delightful account of his rambles in an out-of-the-way corner of Japan, followed in 1891.

When wandering about with a friend in the interior of Japan in the summer of 1891, chance took him up the sacred mountain of Ontaki. His interest in the curious rites of the Shinto pilgrims during their ascent of this Mecca led him to get in touch with the high priests on his return to Tokio. The result was a book on some hitherto but little known aspects of Shintoism.

All this illustrates the versatility of the man, for the real work of his life was the astronomical research of his later years. Is it perhaps a paradox that the foremost believer in intelligent life on another planet shared with many of the scientific men of his days an attitude of robust scepticism on the future life of man? Although far too much in sympathy with the philosophy of the East to fear death in the usual sense, he resented deeply the idea of the termination of his personality, in a way characteristic of men of energy and intellectual force.

During all his early activities Lowell had kept a live interest in mathematics and astronomy. In 1877 the Italian astronomer Schiaparelli began a systematic study of the planet *Mars*, which led to his discovery of a remarkable series of markings which he called *canali*, a word which has been incorrectly translated into canals, and has proved

a source of much subsequent confusion. Lowell followed with deep interest the discoveries of the Italian savant, for the character of the work was calculated to fire the enthusiasm of a man of imagination, of scientific proclivities. By the early nineties Schiaparelli's eyesight had so far failed that it was evident that his observing days were over. And Lowell determined to give his energies and his fortune to continuing the work. Before founding an observatory to be devoted chiefly to the study of the planets, with characteristic intelligence he and his assistants spent many months in a systematic series of explorations and tests to discover the most suitable spot. In order to obtain the best "seeing," it is necessary that the air should be quiet and rarefied. It is a singular fact that most observatories have been placed with a view of being seen rather than seeing, in the neighborhood of great cities or institutions of learning; while the few observatories that are more intelligently placed have not profited by Lowell's discovery that the currents of air swirling about a mountain top make it a far less ideal locality than a plateau. Dr. Lowell visited France and Algiers as well as sites in America, finally deciding upon the great plateau of northern Arizona, where, not far from the San Francisco peaks, he finally built his Observatory at a height of approximately 7,300 feet. An expedition was made to the Mexican Plateau, and one was sent to the Andes of South America, but no place has as yet been found better than Flagstaff at its best.

Around the dome of the original superb 24-inch refracting telescope, erected in 1894, has grown up a small village with quarters for his employees, and separate houses for his assistants, whom he treated with unfailing generosity, courtesy and consideration. Here, under a separate dome, a 40-inch reflecting telescope was also eventually installed, one of whose chief uses has been to establish the uselessness of that class of instrument in the study of planetary detail. Lowell's own house, a low picturesque structure, looks out on as magnificent a view as ever gladdened the eye of a roving man or soothed the spirit of a contemplative philosopher. Below a steep foreground of rugged pines, stretches a broad forest-covered plain, broken with patches of natural park. Directly across rises the mighty mass of the San Francisco peaks, their lower slopes clothed with huge pines, which melt into the stunted vegetation of the higher regions, till the last frost-like verdure is lost in a riotous mass of barren rocks capped with the jagged edges of their snowy summits.

Here for many years Lowell and his staff have accomplished a mass of spectroscopic, photographic, visual and mathematical work of the highest class, which entitles him to a distinguished place in the history of astronomy. And these priceless records have not, as is so often the

case, been buried in a scientific mausoleum. Photographic transparencies of planets, comets, nebulæ, star groups and unique spectrograms which show the nature of the planetary atmospheres, their speeds of rotation, etc., have been most generously exhibited; whereby a host of people will forever have a living conception of this mighty universe of which we are a part. It was Dr. Lowell's heart's desire that the work of the Observatory be forever continued. Most befitting, it seems, that he chose as his trustee a man of art and science, his cousin, Guy Lowell.

One of the chief ends in view in the establishment of the Lowell Observatory was for the observation of the delicate markings on *Mars*. No one of good eyesight and open mind, who has enjoyed the privileges of a protracted study of the planet, under the unique advantages enjoyed at Flagstaff, can doubt the correctness of the essential facts; it is purely a question of their interpretation. The surface of *Mars* is covered with an extraordinary network of singularly artificial looking lines. The intensity of these lines waxes and wanes in periods that show a remarkable relation to the melting of the winter polar snow caps. The atmosphere of *Mars* is rarefied, but we cannot say that it is insufficient to support some sort of intelligent life. The planet appears to have but little water on its surface. If we adopt Lowell's theory that the intelligent inhabitants of a dying *Mars* are struggling to keep alive by a planet wide system of irrigation, from the water of the melting polar snow caps, we shall find that the theory accounts for all the observed facts. He supposes that all the so-called "canals" are bands of cultivated vegetation dependent on some system of irrigation forced down their centers. It is these bands of vegetation which we see, and not the water irrigating them. Just as an observer at a distance from our earth would see the fertile strip of the valley of the Nile stand out against the desert long before he could distinguish the river. Moreover, it is found that the intensification of the markings on any part of the planet's surface takes place a sufficient time after the beginning of the melting of the adjacent polar snow cap to allow for the water to reach that point and the crops to grow.

It is only human that such a startling theory should meet with determined opposition. But since none of the alternative theories offered by his opponents account for the observed facts at all, it would seem that Lowell's theory deserves the serious consideration of intelligent men. Schiaparelli himself called it "the best working hypothesis yet devised."

Ever since the earliest men of science endeavored to prove that the earth was round, humanity has bitterly resented any discovery that has tended to diminish the cosmic importance of the earth or belittle

man's place in the universe. The objections that have been brought forward to smother Lowell's theory are of precisely the same character as those used in attempting to stifle the work of Copernicus, Galileo and Darwin.

Much of the published work of the Observatory is to be found in the "Annals of the Lowell Observatory," Vol. I, 1896; Vol. II, 1900; Vol. III, 1905; the "Bulletins"; and two memoirs: No. I, 1915, "Memoir on a Trans-Neptunian Planet" in which the results of many years of painstaking labor in the analysis of the disturbances produced by this unknown body on the outer planets, determined by the methods of celestial mechanics, have rendered the existence of such a body certain, although it still eludes the search which has been made for it on photographic plates; and No. II, 1915, "Memoir on *Saturn's* Rings" which treats of the internal constitution of the planet as evidenced by the divisions. Besides these strictly scientific publications, there have been many in which Dr. Lowell has clothed the dry bones of scientific specification with flesh and made them live in works whose brilliancy and charm can hardly be excelled. Among these are "*Mars*" (1895); "The Solar System" (1903); "*Mars* and its Canals" (1906); "*Mars* as the Abode of Life" (1909); "The Evolution of Worlds" (1910); "The Genesis of the Planets" (1916). A complete list of Lowell's writings would have to include numerous articles in various magazines and proceedings of learned societies. He has delivered many lectures in the United States and Europe on a wide range of subjects, and has appeared before the most important scientific societies in the world.

TWENTIETH MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

The twentieth meeting of the American Astronomical Society was held in conjunction with the American Association for the Advancement of Science at Columbia University, New York City, from December 27 to 29, 1916. This was the seventieth meeting of the Association and the first of the greater quadrennial meetings, for which an effort is made to have all of the affiliated societies in attendance.

The account of the meeting should, however, begin with the evening of Tuesday, December 26, when all the members of our Society, who were in New York, joined the audience assembled at the Museum of Natural History to hear Professor W. W. Campbell deliver his retiring address as President of the American Association. His topic was "The

Nebulæ." Though not a part of the program of the Society as such, it was beyond a doubt the most important astronomical communication to which its members had the privilege of listening, and we went away hardly knowing whether to admire most the accomplishment of condensing the great mass of material into an hour's address, the superb series of lantern slides which illustrated it, or the courage of our friend, who though ill delivered his message in such a manner that most of his two or three thousand hearers must have known nothing of his disability.

The scientific sessions of the Society were held in Fayerweather Hall on Wednesday, Thursday, and Friday mornings at ten o'clock, and Friday afternoon at two.

On Thursday afternoon the Society met in joint session with the American Mathematical Society, the Mathematical Association of America, and Section A of the American Association and heard addresses by two of our members upon their retirement from important offices: Professor E. W. Brown, the retiring President of the American Mathematical Society, upon "The Relation of Mathematics to the Natural Sciences"; and Professor A. O. Leuschner, retiring Vice-president of Section A, upon "Derivation of Orbits, Theory and Practice", which, in his absence, was read by Professor Haskell of Columbia. Both addresses were of much interest to astronomers, and the two supplemented each other in a striking fashion. Professor Brown's scholarly survey of the general field laid especial emphasis upon the importance of the problem of adapting mathematical methods and symbolism so that numerical results may be most accurately and economically obtained, while Professor Leuschner's review of a particular problem supplied an admirable example of a successful accomplishment of such an adaptation.

On Thursday evening the Societies which had combined in the afternoon met again at dinner at the Park Avenue Hotel. In comparison with the teeming ranks of the mathematicians, the astronomers seemed rather "a feeble folk" numerically; but it was evident that our more numerous colleagues had heard of the success of our last meeting and envied us our good time, judging from the remarks made by the genial toastmaster, Professor Eisenhart, in introducing our good host of last August, Professor Miller, as the representative of astronomy in the after-dinner speaking.

Wednesday afternoon had been set apart for committee meetings, and very wisely as it proved, for at the end of the first paper, "Daylight Saving Movement", Professor Jacoby offered the following resolution which was adopted by the Society:

> *Resolved* that a committee of five be appointed by the President; that the President be a member of said committee; that the

committee be authorized to make a public statement in behalf of organized astronomy in the United States concerning the proposed daylight saving plan.

The committee, composed of Messrs. Jacoby, *Chairman*, Poor, Russell, Schlesinger, and Pickering, after a continuous session of rather more than four hours, offered the following report:

(1) The chief objects of the Daylight Saving Plan are: (a) to facilitate earlier rising in summer than in winter; (b) to increase the hours of daylight available after the day's work, for recreation or other purposes; and (c) to conserve to the nation as a whole a part of the fuel now being consumed in the production of artificial light.

(2) The plan which has been proposed for the United States, and which has been adopted as a war measure in England, France, and Germany, as well as in Holland, consists in advancing the legal time one hour during part of the summer half of the year. In the United States, this amounts to a simple shift of the boundaries of existing standard time zones.

(3) In order to be of real benefit, the plan must be adopted simultaneously by a large majority throughout an extended area of the United States.

(4) It is to be noted that the advantages of the plan become less as we approach the extreme southern part of the country, because the hours of daylight are more nearly the same throughout the year in lower latitudes. For this reason, this committee suggests that a modification of the proposed plan might be advisable for the United States.

(5) If Daylight Saving is adopted, this Committee recommends that, in order to obviate the introduction of terms that may prove misleading, the names now in use to describe standard time be continued with unchanged meaning; thus: in Chicago, Central Time would be used in winter as at present, and Eastern Time in summer.

(6) The proposed plan involves no advantages in scientific work, nor does it entail serious disadvantages. Meteorological observers would continue their present practice of making their observations at a specified Eastern Standard Time throughout the country. The changes in time could easily be taken into account in the preparation of Tide Tables and similar publications.

(7) The chief objections to this proposal which have been brought to the attention of the Committee are the following:

(a) In all civilized countries, the middle of the working day is not noon, but somewhat later. Under the proposed plan, it would sometimes come before noon, and usually earlier than the experience of mankind appears to have justified.

(b) Artisans who begin work early would have to get up in the

dark, thus undergoing serious inconvenience, and at times using more instead of less light, and also at some seasons requiring more fuel.

(c) The setting back or forward of all clocks by an hour on two days in each year will involve inconvenience and annoyance.

(d) "Not a single scientific society or other body with expert knowledge has supported it." (*Nature*).

(8) The Committee is unanimous with regard to sections (1) to (6) above, but are not agreed as to the weight that should be attached to the disadvantages enumerated under (7). Two members, Jacoby and Schlesinger, favor the adoption of the plan as proposed, and are convinced it would be highly beneficial; a third, Poor, believes the plan should be put into operation, but for the present as an experiment. The two remaining members, Pickering and Russell, believe that the disadvantages distinctly outweigh the advantages, and are opposed to the adoption of the Daylight Saving Plan.

This report was read to the Society at the meeting on Friday afternoon, December 29. A "straw vote" of the members present was taken with the results:

In favor of Daylight Saving Plan	8
Opposed to the Plan	7
Neutral	14
Total	29

Professor Schlesinger presented a report of progress from the Committee on Associate Membership and the committee was continued.

At the concluding session of the Society, the following resolution was presented by Professor Russell and adopted:

Resolved: that a committee be appointed to consider the securing of observations of variable stars.

President Pickering appointed as members of this Committee Messrs. William T. Olcott, *Chairman*, Leon Campbell, D. B. Pickering, and H. N. Russell, with power to add to their number.

A letter from Professor A. E. Douglass, expressing his gratitude to the Society for the assistance which its resolution of August 28, 1914, had given in causing the gift to the University of Arizona of $60,000.00 toward the establishment of an Observatory, was read to the Society as follows:

"October 17, 1916.

Secretary, American Astronomical Society,
Northwestern University,
Evanston, Illinois.

My dear Professor Fox:—

Two years ago the American Astronomical Society did me the courtesy to pass a resolution expressing interest in the establishment of an observatory in such a favorable location as this of the University of Arizona. I am happy to say that

this resolution, together with letters from several prominent astronomers along the same line, has assisted in procuring an anonymous gift to the University of $60,000 for this purpose, and I take this way of expressing my deep obligation to the Astronomical Society for its resolution of August 28, 1914.

Sincerely yours,
(Signed) A. E. Douglass."

In compliance with an invitation from the National Research Council that the American Astronomical Society should join them in forming a Committee on Astronomy for the promotion of research, Professor E. W. Brown presented the following resolution, which was unanimously adopted:

Resolved: 1. That the Council of the American Astronomical Society approves of the suggestion that the Society coöperate with the National Research Council and the Committee of One Hundred of the American Association for the Advancement of Science in forwarding the interests of research.

2. That the Council of the Society will appoint one or more of the members of the Society to act on the Committee on Astronomy of the National Research Council when requested to do so by the Chairman of the Council or by the proper official representing the Council.

New members to the Society were elected as follows:

1. Tilton C. H. Bouton, Hudson, N. H.
2. William Bowie, U. S. Coast & Geodetic Survey, Washington, D. C.
3. Frederick E. Brasch, 9 Museum Street, Cambridge, Mass.
4. Theodore Henry Brown, 79 Taber Avenue, Providence, R. I.
5. Wallace Campbell, Mt. Hamilton, California.
6. Howard O. Eaton, 428 Lake Street, Madison, Wis.
7. Miss Ernestine Fuller, 108 Mercer Street, Princeton, N. J.
8. G. L. Harrell, Millsaps College, Jackson, Mississippi.
9. Lloyd K. Jones, Kodak Park, Rochester, N. Y.
10. Charles Y. McAteer, 2953 Sacramento Street, Pittsburgh, Penn.
11. C. E. K. Mees, Kodak Park, Rochester, N. Y.
12. Lewis Leroy Mellor, Detroit Observatory, Ann Arbor, Michigan.
13. Forrest H. Spinney, Hudson, N. H.
14. Russell Sullivan*, 1545 North Meridian Street, Indianapolis, Indiana.

* Mr. Russell Sullivan was elected to the Society in October, 1916 after the circulation of a petition for membership through the mails, according to the method authorized at the Swarthmore meeting.

The attendance was large, forty-nine members being present, but was unevenly distributed geographically, two-thirds of those present coming from the North Atlantic sea-board states:

S. I. Bailey
S. G. Barton
L. A. Bauer
William Bowie
E. W. Brown
T. H. Brown
W. W. Campbell
Annie J. Cannon
F. E. Carr
J. B. Coit
C. R. Cross
C. H. Currier
R. S. Dugan
J. C. Duncan
Ernestine Fuller
C. H. Gingrich
W. E. Glanville
W. L. Hart
G. L. Harrell
H. B. Hedrick
Mary M. Hopkins
H. Jacoby
Louise F. Jenkins
E. S. King
Otto Klotz
O. M. Leland
H. C. Lord
E. S. Manson
P. W. Merrill
W. I. Milham
S. A. Mitchell
J. A. Miller
D. B. Pickering
E. C. Pickering
J. S. Plaskett
J. M. Poor
H. Raymond
W. F. Rigge
E. D. Roe
J. T. Rorer
H. N. Russell
Frank Schlesinger
Frederick Slocum
H. T. Stetson
A. B. Turner
F. D. Urie
C. E. Van Orstrand
F. W. Very
W. R. Warner

In addition to the members, the following visitors were present:

Fred Allison, H. Arctowski, Louis Bell, Miss Dorothy Block, H. T. Dunham, J. P. Henderson, Miss Florence Lewis, Miss Frances Lowater, Miss Antonia C. Maury, F. M. Moore, B. L. Newkirk, Miss Wertha Pendleton, Mrs. J. S. Plaskett, E. V. Putnam, B. P. Weinberg, Mrs. E. Newcomb Wilson, Miss Emma R. Williams, Mr. and Mrs. Isaac Winston, and R. A. Wetzel.

At the concluding session of the Society, the following resolution was unanimously carried:

Resolved: That the Secretary be instructed to extend to the authorities of the Columbia University the thanks of the Society for the hospitality extended to it at this meeting.

The account of this meeting has been prepared from the notes of the Acting Secretary, Professor Henry Norris Russell.

The abstracts of papers presented are given below in the customary alphabetical order.

(*To be continued*).

THE NATURE OF MATTER.

J. C. WHITEHORN*

From the time when men began to wonder at the world and ponder its problems they have puzzled over the nature of the universe. Sensing an external world of objects and feeling the vital necessity of dealing with these objects, they have sought for an understanding of the universe which would give them a mastery over it. And in their more contemplative moments they have tried to attain to a more comprehensive view which would not only be serviceable in handling objects but would also give a true presentation of the reality of the universe. Through the whole range of solutions offered one can find an ever-present attempt to conceive the universe in some unitary and comprehensive manner. Some have looked upon it as a chance collection of dead atoms propelled by blind force; others as pure idea or thought. Between these two extremes there have been all sorts of gradations and compromises.

The unreflective attitude of the average man, which may be called the common sense view, is that there is a certain substance or matter back of the phenomena of nature. This primary matter has certain properties such as color, odor, taste, etc. The phenomena of nature consist of the activities of this matter. Common sense, then, postulates three planes or kinds of reality, (1) a substratum of matter or substance, (2) the properties inherent in this substance, and (3) the activities of this substance.

This näive solution is, however, quite unsatisfactory. In the first place, it is practically impossible to draw a fast line between activities and properties. For example, luminosity was formerly thought to be a property of matter, now it is considered an activity of matter. Activities and properties merge into one another until we can find no satisfactory line of demarcation.

In the second place, no one ever saw, heard, felt, tasted or smelled "matter." All of our knowledge of objects is a knowledge of properties, not of a "matter" or "substance". An object, as known to us, is simply a self-subsistent organization of properties. The idea of a hard and changeless block of reality which serves as a support to these properties is a purely metaphysical assumption.

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And yet, even though there is no logical necessity, we feel a psychological need for the idea of a matter or substance to which we can *fasten* the qualities, as it were. The basis for this psychological need can probably be found in those universal and stable properties, extension and mass. We see about us objects undergoing various transformations of color, odor, density, etc. Most of the properties seem to be variable and changing, and sometimes absent altogether. But there are certain properties which are universally present in all objects, under all conditions and through all changes. These universal properties are mass and extension. Their persistency and universality indicate a "something" which endures and is constant through the changes. Hence, there has unconsciously grown up in our thought a concept of a stable and universal substance or matter which lies back of and gives support to the varying properties.

If, however, we think soberly and consistently upon the matter we shall come to the conclusion that this is a fault of unreflective thought, which has seized upon the more stable and enduring properties as a support for the variable and changing. Extension and mass are, in fact, merely those properties which are more permanent and universal. There is no logically necessary implication or assumption of any material entity, as ordinarily understood.

Let no one think, however, that by this statement we deny the existence of external and objective reality. We are not trying to reduce the world to a phantasmagoria of subjective ideas. We are attempting to get rid of a troublesome metaphysical assumption as to the nature of this objective reality. *Our purpose is to ascertain as accurately as possible the true nature of reality, and more particularly of that phase of objective reality commonly known as matter.*

We shall strive to conduct this investigation in the genuine spirit of a seeker after truth and therefore we shall consider of primary importance what Science has to say upon the subject. And Science has much to say. Modern physical research has shed great light upon this problem. The strange and erratic behavior of cathode rays and of the emanations of radio-active substances has greatly modified our conceptions of matter.

We shall take up first a discussion of those phenomena which occur when electricity is conducted through rare gases. If an electric current of high potential be passed through an air-tight glass tube containing gas at atmospheric pressure, an ordinary spark will be produced, just as in the atmosphere. If, however, the gas be somewhat exhausted, so as to create a partial vacuum, the current, which need not now be of high potential, will pass readily through the tube. Its passage will be marked by curious phenomena. The negative electrode (cathode) will

be covered by a luminous layer. Next to this is a dark space, the Crookes dark space. Beyond this is a luminous part called the negative glow, and beyond this glow another dark space, the Faraday dark space. Between this and the anode is the positive column of alternately dark and light spaces called striæ.

If the gas be still further exhausted to a pressure of about .01 mm the above phenomena disappear and a bright phosphorescence appears on the sides of the tube. This phosphorescence is produced by radiations of very minute particles issuing in straight lines from the cathode. If a solid body be placed inside the tube so as to intercept the rays, it will cast a well-defined shadow. If the rays be focused upon a body, it may be heated even to incandescence. But what is of much more significance, these particles can be deflected from their normally straight path by means of a magnet. This indicates that the particles are either themselves magnetic or are electrically charged so that their motion sets up lines of magnetic force.

Perrin and later J. J. Thompson have shown that the deflection by a magnet is due to a negative charge of electricity carried by the particles. If the end of a conductor, carefully insulated and protected, be placed *near* a pencil of cathode rays, an electrometer connected to this conductor will show very little effect. But if the rays be deflected so that the particles fall directly *upon* the conductor, the electrometer shows a considerable negative charge. Furthermore, if a pencil of cathode rays be passed between two parallel plates which are oppositely charged at a great difference of potential, the beam of rays will be deflected *towards* the *positive plate*. These experiments indicate that *the cathode particles carry a negative charge of electricity.*

This gives us a clue as to the method of finding the velocity of these rays. Measurements have shown that a moving charged particle produces a magnetic field which is equal to the field produced, per unit of its length, by a linear conductor carrying a current equal to eV, where e is the charge on the moving particle and V is its speed. [1] Hence if the speed of a cathode particle is V and its charge e, its magnetic field is eV. If a magnet be brought to bear with field intensity H upon the cathode particle, the particle will be deflected from its path by a force HeV (the product of the two magnetic forces) and will follow a curved path.

Suppose now that two parallel plates be placed on opposite sides of the pencil of rays and a high difference of potential established between them in such a way as to pull the charged particles in the opposite direction from that in which the magnet deflects them. The electric force acting on the particle will then be the product of the charge on the particle times the strength of the electric field. If the latter be X,

the force will be eX. Now the magnetic and electric fields, which counteract each other, can be so adjusted that there will be no deflection, at which time the opposing forces are equal. That is, eX equals HeV. Then V equals X/H. Now X and H can be measured and hence V can be calculated. By this method Thompson has found the velocity of cathode particles to be 2.8×10^9 cm per sec., which is about one-tenth the velocity of light (29.99×10^9).[2] The value for V varies slightly with the potential in the tube, but is fairly constant.

If we now remove the electric field and measure the deflection caused by the magnet, we can calculate the radius of the curve of deflection. The force producing this deflection is from the above discussion HeV. The centrifugal force of the particle whose mass we shall call m, moving with speed V in a circle of radius r, is, by mechanics, mV^2/r. Action and reaction are equal, hence

$$HeV = mV^2/r. \quad \therefore V/Hr = e/m.$$

Now H can be measured, r can be calculated and V can be determined as shown above. Hence the ratio e/m can be found. Thompson, by this method, obtained a value for e/m of 1.7×10^7.

The values of V and e/m have thus been shown to be interdependent. This indicates an intimate relationship between the velocity, the charge and the mass. Since V, e and m have been practically constant in the above mentioned experiments, we have been unable to determine the nature of their inter-relationship. We must search for a case in which these values are variable in order to find their mutual relations.

Such a case has been found in the radium emanation. The phosphorescent action of the cathode rays led scientists to investigate phosphorescent substances. Investigation of uranium salts and pitchblende ores led to the discovery by Mme. Curie of the element radium. This substance seems to defy the laws of physics. It constantly gives off an enormous amount of energy without seeming to lose weight or be consumed. This energy is given off in the form of radiations. Ernest Rutherford has found that these radiations are composed of three distinct types of rays, called the alpha, beta and gamma rays. Becquerel showed that the beta rays behave in every respect like the cathode rays. They are composed of negatively charged particles having the same relations between mass, speed and charge as do the cathode particles. Becquerel, by practically the same method as Thompson used for cathode particles, determined the velocity and the ratio e/m for the beta rays. The value which he found for e/m does not differ much from the value of e/m found by Thompson for the cathode particles (1.7×10^7). He observed, however, that the velocities varied from 6×10^9 to 2.8×10^{10} cm per sec.

This variation in velocity led Kaufmann to make more accurate determination of e/m to find whether the value of this ratio varied with the velocity .He made the very important discovery that *e/m decreases when the speed increases.*[3] If we assume that the charge e is constant, then *the mass* of the beta particle *appears to increase with increase of velocity.* This is not the old law of mechanics that the *momentum* varies with the speed, but a new discovery that the *mass itself varies with the speed.* Now it seems to be quite well established at least for bodies of appreciable size, that the mass of an *uncharged* particle does not vary with the velocity. This renders it very probable that the variation of the mass of a beta particle with the velocity is due to the electric charge.

Indeed, if we stop to reflect, we can find other considerations which would lead us to the conclusion that an electric charge on a moving body will affect its mass. Suppose that a certain force F is applied to an uncharged particle, imparting to it a certain acceleration a. If now the same particle be *charged*, the force F will be unable to impart to it the same acceleration, because the force not only has to overcome the same inertia as before, but also, by moving the charged particle, sets up lines of magnetic force. By the law of the conservation of energy, this force cannot be created from nothing. Additional force is required to set up these magnetic lines. Hence more force will be required to produce the same acceleration. Now by Newton's second law F equals ma. Then m equals F/a. Hence in the case of the uncharged particle considered above, m equals F/a; but in the case of the charged particle m equals $(F+f)/a$. In other words, the *mass of the particle has been increased by the electric charge which it carries.* The increase of mass depends upon the magnetic field set up and this depends, in turn, upon the amount of electric charge and the speed of the moving particle. Therefore the mass of a particle carrying a constant charge is a function of the velocity. It must furthermore be remembered that, when magnetic lines have once been set up, they tend to keep the particle in motion. Hence in either case, whether of negative or positive acceleration, an electric charge on a particle increases its mass.

These theoretical considerations (which, it must be rembered, deal only with moving particles) bear out the empirical findings of Kaufmann. We can therefore conclude that the mass of the beta particle is due, *in part at least*, to the moving charge. And if in part, then why not altogether? There is scientific material which seems to indicate that *the whole mass* is due to the charge and its velocity.

J. J. Thompson has worked out mathematical formulæ for the mass of a moving charged particle. He has shown that the part of the mass

due to the moving charge (the "electrical" mass, as it were,) is $2\alpha e^2/3a$, where e is the charge, a the radius of the particle and α a variable depending upon the velocity. This variable α is taken as unity when V is very small compared to the velocity of light, and becomes larger as V approaches the velocity of light. The variable α is the ratio of the mass at any given speed to the mass at a certain slow speed (taken as unity). Thompson has calculated the value of α at different velocities. The results are given in the following table, where they are compared with certain experimental results of Kaufmann. The latter has worked out experimentally the values of e/m at different velocities. With these results and taking the mass at a certain slow speed as unity, he has calculated the ratios of the mass at different speeds to this unit mass. His experimental results for the whole mass agree with Thompson's theoretical calculations for the electrical mass within the limits of experimental error, as shown by the following table.[4]

	KAUFMANN	THOMPSON
Velocity in cm per second	Ratio of *whole* mass at given velocity to *whole* mass at slow velocity (taken as 1)	α the ratio of *elec.* mass at given velocity to *elec.* mass at slow velocity (taken as 1)
2.85×10^{10}	3.09	3.1
2.72×10^{10}	2.43	2.42
2.59×10^{10}	2.04	2.0
2.48×10^{10}	1.83	1.66
2.36×10^{10}	1.65	1.5

This close agreement leads us to conclude that *the electrical charge and its motion are sufficient to account for all the mass of the particle.* Mass is wholly a product of electrical charge and motion.

The objection will instantly be raised that such a conclusion is untenable, for all are familiar with the fact that uncharged bodies have mass. But an uncharged body is a rather difficult thing to define. It is, in the first place, merely a *relative* distinction. When we speak of a body as "uncharged" we mean that there is no difference in electrical potential between it and the earth. In the second place the term "uncharged", when applied to a body, means simply that the body, *as a system*, is at the same potential as the earth. It does not mean that there is no electricity in the body, but that what charges of electricity there may be are *balanced* so that the system does not show them. Thus copper sulphate may be dissolved and dissociated in water. Under such conditions it most certainly shows evidences of the presence of electrical charges. But these charges are of opposite kinds and are present in such amounts as to exactly balance so that when the $CuSO_4$ is precipitated the one kind of electricity exactly balances the other and the precipitate gives no evidence of their presence. We say that

the precipitate is uncharged, whereas in fact the particles of which the precipitate is composed are fairly alive with charges which will reappear if the copper sulphate is again dissociated. Thus we see that a body might be entirely made up, in its inner constitution, of disembodied charges moving about with great velocity, while the body as a whole showed no signs of this electricity and hence would be "uncharged." If these disembodied charges were continually moving at uniform speed, their masses and consequently the aggregate mass of the whole body would be constant, and would not be affected by movements of the body as a system. Thus the fact that uncharged bodies have mass does not invalidate the hypothesis that mass is due to electric charges in motion, for the mass of such an "uncharged" body may be due to the rapid movement of *internal* charges which are *equally balanced* and hence do not give any charge to the body as a system.

From the consideration brought forward above, showing that mass varies with velocity, that an electric charge in motion can produce mass, and that these factors of charge and motion are sufficient to account for all the mass, we are led to the conclusion that mass is not a primary but a secondary quality and is derived from an electric charge in motion. We are now in a position to make the hypothesis that *matter is composed altogether of electrical charges*, which, by their motion, give to bodies their mass.

This hypothesis has been worked out quite in detail by Thompson, Rutherford and others, and it serves so well to explain the phenomena of physics and chemistry that it is coming to be generally accepted. It is called the corpuscular or electron theory.

I cannot hope within the limits of this paper to undertake a comprehensive discussion. I will have to leave untouched a great mass of interesting facts and a whole body of new theory concerning the bearing of this new idea upon such phenomena as heat, polarization, electrical and thermal conduction, incandescence, etc. I will attempt only to indicate the general outlines of the theory and to point out its application to a few phenomena.

The beta particles and the cathode particles, which are identical in their properties, are taken to be the unit of electrical charge and are called *electrons* or *corpuscles*. The atom is thought to be made up of corpuscles. But corpuscles are negative charges and hence repel each other. There must therefore be a *positive charge* which holds them together in the atom. The form in which this positive charge occurs in the atom is at present a matter about which we have very little information.

Thompson, in his calculations, considered that the positive charge was spread with uniform density through a sphere of quite large radius,

within which the corpuscles were arranged.[5] Rutherford has shown, however, that the distribution of positive electricity assumed in the Thompson atom was far too diffuse to account for many facts which have later been discovered. According to this view of Rutherford's, the positive electricity is concentrated in a very minute nucleus which is thought to have a radius of 1/1800 of that of the negative electron.[6] But this minor disagreement need not divert us from the main consideration, for the difference between these two views is merely a refined and technical distinction. Rutherford's view is more in accordance with observed facts but in order to present Thompson's work as originally developed we will adhere to his theory of a sphere of positive electrification of uniform density.

The positive electricity attracts the corpuscles toward the center of this positive sphere, while their mutual repulsion drives them away from it; when in equilibrium they will be distributed in such a way that the attraction of the positive electrification is just balanced by the mutual repulsion of the corpuscles. When there is only one corpuscle it will of course go to the center of positive electrification; two corpuscles will be in equilibrium on opposite sides of and at equal distances from this center; three, at the corners of an equilateral triangle; four, at the corners of a regular tetrahedron; and six, at the corners of a regular octahedron, the center of each of these configurations being at the center of the positive sphere.

Thompson has been unable to work out the arrangement of more than six corpuscles in three dimensions. He has, however, solved the case where the corpuscles are confined to a plane passing through the center of the positive sphere. According to his calculations, stable equilibrium is assured when the corpuscles are arranged in concentric rings as follows: for numbers of corpuscles from 2 to 5, one ring; from 6 to 16, two rings, 5 to 11 in the outer ring; from 17 to 31, three rings, 11 to 15 in the outer ring; from 32 to 48, four rings, 15 to 17 in the outer ring; from 49 to 69, five rings, 17 to 21 in the outer ring; from 70 to 93, six rings, 21 to 24 in the outer ring. A complete table is given on pages 109-110 of Thompson's "The Corpuscular Theory of Matter" showing the number of rings and the number of corpuscles in each ring for groups of corpuscles ranging in number from 1 to 100.

Let us take for example the arrangement of corpuscles in those configurations which have 20 in the outer ring. The table on the following page gives the number in each ring.[7]

The group of 59 corpuscles shown in Column A has 20 in the outer ring, 16 in the next, 13 in the next, 8 in the next and 2 in the inner ring. Suppose that the charges in this group balance, i. e., that the positive charge equals the sum of the negative charges of the corpus-

Ring	A	B	C	D	E	F	G	H	I
5th (outer)	20	20	20	20	20	20	20	20	20
4th	16	16	16	17	17	17	17	17	17
3rd	13	13	13	13	13	13	14	14	15
2nd	8	8	9	9	10	10	10	10	10
1st (inner)	2	3	3	3	3	4	4	5	5
Totals	59	60	61	62	63	64	65	66	67

cles. If an additional corpuscle were shot into the group, the 60 corpuscles would then arrange themselves with 20 in the outer ring, 16 in the next, 13 in the next, 8 in the next and 3 in the inner, as in Column B. Since the positive and negative charges at first balanced, this new group in Column B has one excess negative charge. If two corpuscles were shot in, the group would then have two excess negative charges, and the 61 corpuscles would be arranged as shown in Column C. If three were shot in, the group would have three excess negative charges and the 62 corpuscles would be arranged as shown in Column D. Similarly, if 4, 5, 6, 7 or 8 corpuscles were shot in, the groups would have 4, 5, 6, 7, 8 excess negative charges and the 63, 64, 65, 66 or 67 corpuscles would arrange themselves as in Columns E, F, G, H and I. These arrangements would all be stable. If, however, more than 8 corpuscles were shot in, the rearrangement would put 21 in the outer ring, and so would pass outside the group we are considering. Moreover, it would be loading a disproportionate number of corpuscles upon the comparatively small positive charge, which it must be remembered is the same as in Column A. These arrangements then would tend to eject corpuscles and come back to one of the forms with 20 in the outer ring. The stable groups then have 59, 60, 61, 62, 63, 64, 65, 66 and 67 corpuscles and have respectively 0, 1, 2, 3, 4, 5, 6, 7 and 8 excess negative charges.

If, however, instead of starting with an evenly-balanced group of 59 corpuscles, we had started with the group of 67 corpuscles with a positive charge sufficient to balance them and, instead of shooting corpuscles in, had taken them away, the resulting groups would have had 66, 65, 64, 63, 62, 61, 60 and 59 corpuscles, respectively, and would have had excess *positive* charges of 0, 1, 2, 3, 4, 5, 6, 7, 8.

The group having an excess positive charge of, say, 2 would attract to itself either two groups with an excess negative charge of one each or one group with an excess negative charge of two. That is, the number of excess positive charges measures the attraction for negative groups, and hence may be considered the electro-negative valency. Similarly the number of excess negative charges may be considered the electro-positive valency. We can now give a table showing these results:

Group Letter	A	B	C	D	E	F	G	H	I
No. of Corpuscles	59	60	61	62	63	64	65	66	67
Electro-positive valency obtained by shooting electrons into 59 (A)	0	1	2	3	4	5	6	7	(8)
Electro-negative valency obtained by taking electrons from 67 (I)	(8)	7	6	5	4	3	2	1	0

These groups are arranged according to the number of corpuscles they contain. The valency is seen to be a function of the number of corpuscles. Now, since we have shown that mass is due to electric charges, if there actually exist atoms analogous to these groups, the number of corpuscles of which they are composed would determine their atomic weights. Hence the valency, being a function of the number of electrons, would be a function of the atomic weight. The corpuscular theory then, as worked out by Thompson, leads to the conclusion that valency is a function of atomic weight.

If we were to take up a consideration of those groups of corpuscles having 21 in the outer ring we could in like manner show that the valencies of this group would run from 1 to 8, with an additional group with valency 0 (signifying an inert group) at each end. This would indicate that valency is not only a function of the atomic weight but also a periodic function.

This theoretical deduction from the corpuscular hypothesis is amply confirmed by empirical science. The periodic tables of the elements arranged by Mendeleeff and Meyer show clearly that not only valency but many other properties as well are periodic functions of the atomic weights. The following short table illustrates this fact, with reference to valency:

El.	He	Li	Gl	B	C	N	O	F	Ne	Na	Mg	Al	Si	P	S	Cl	Arg
At. wt	4	7	9.1	11	12	14	16	19	20	23	24.4	27	28	31	32	33.5	39.9
+Val.	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7	0
−Val.	0	7	6	5	4	3	2	1	0	7?	6?	5	4	3	2	1	0

One can ask for no more beautiful confirmation of any hypothesis than this confirmation of the corpuscular theory by the Periodic Table of the elements.

This confirmation is still more remarkable when we realize that Thompson's calculations have all been based upon the arrangement of corpuscles in a plane. It is to be hoped that three-dimensional arrangements will soon be calculated. If this can be accomplished it will probably give us a still clearer insight into the inner constitution of the atom.

If we return to a consideration of Thompson's groups we shall find that, according to his hypothesis, the atom of one element could be changed into the atom of another element by the loss or gain of one or more corpuscles. This would be equivalent to a transformation of matter. A few years ago such a theory would have been scoffed at and ridiculed. But here again empirical investigation has supported the theory. Ernest Rutherford, through a study of radio-active substances, has found that such transformations are actually taking place.[8]

Radium, as mentioned earlier in this paper, is continually giving off radiations. These radiations are of three kinds, alpha, beta and gamma. The first kind of radiations, the alpha rays, are composed of alpha particles. The alpha particle is very heavy, having four times the atomic weight of hydrogen. It carries two unit positive charges. It is thought to be an atom of helium, carrying twice the ionic charge of hydrogen. The alpha particles furnish the positive electrification for the atom. The beta rays are composed of beta particles, which are simply corpuscles or electrons. The sudden emission of the beta particle or electron from the atom produces an electro-magnetic disturbance in the ether, just as the sudden stopping of a cathode particle produces an X-ray. These electro-magnetic pulses produced by the emission of beta particles are called gamma rays and behave exactly as X-rays.

Now, it is quite evident that the emission of these constituent parts of the atom, the alpha and beta particles, would result in a transformation of the atom. And so it does. All radio-active elements undergo these transformations. Radium furnishes a typical example. It was stated above that radium gives off alpha, beta and gamma rays. This is not strictly accurate for it has been found that these rays arise from a mixture of radium and some of its transformation products. Pure radium emits only alpha particles. The expulsion of an alpha particle transforms the radium atom into the atom of a new element, called radium emanation. This transformation takes place by geometrical progression at the rate of one-half in 2,000 years.[9] That is to say, one-half of a given quantity of radium will be transformed into radium emanation in 2,000 years, one-half of the remainder in another 2,000 years, etc. Theoretically this would mean that there would always be a residue of radium but practically the radium would be completely transformed in about 100,000 years.

A moment's consideration will show that radium must be produced from some other substance, else the supply would long ago have been exhausted. Rutherford has shown that radium is a product of ionium and he has traced its transformations as far back as uranium. The whole series of transformations have been worked out from uranium to

an end product thought to be lead. The following table gives the series:[10]

Element	Ur	UrX_1	UrX_2	Ur2	Io	Ra	Ra Eman	Ra A
Emitted Particle	α	β	β	α	α	α	α	α
Half-Period	5×10^9 yrs.	24.6 days	1.14 min.	10^6 yrs.	2×10^5 yrs.	2000 yrs.	3.85 days	3.0 min.

Element	Ra B	Ra C_1	Ra C_2	Ra D	Ra E	RaF Pol	Lead (?)
Emitted Particle	β	α	β	β	β	α	
Half-Period	26.8 min.	19.6 min.	1.38 min.	16.5 yrs.	5 days	136 days	

If we trace the story of this changing atom, we find it first as the atom of a fairly stable element uranium. But this stable atom in time expels an alpha particle and by a rapid series of further expulsions and rearrangements it is transformed into the atom of an element called Uranium 2. This is also a fairly stable element, but in time this atom also expels an alpha particle and becomes ionium. The atom of ionium gives off another alpha particle and becomes radium. It then undergoes a remarkable series of comparatively rapid changes, becoming at last the stable element lead. This, in bare outline, is the tumultuous and kaleidoscopic history of an atom.

This discovery by Rutherford of the actual transformations of real atoms has revolutionized scientific thought. The corpuscular theory has again been empirically confirmed, and so emphatically that widespread acceptance has been secured. The atom seems no longer the unchanging and indivisible piece of a material entity we had once thought. It appears now as a microcosm—a universe of energy in motion, with inner possibilities of disintegration and transformation.

There is, however, a difficulty which some have felt in accepting this theory that matter is essentially only energy in motion. It will be recalled that in the beginning of this discussion attention was directed to the fact that the two great empirical supports for the metaphysical idea of a material entity were the properties of extension and mass. Now, the advocates of the electron theory have shown very conclusively that mass is altogether due to disembodied charges of electricity in motion, and hence that no material entity need be postulated to account for mass. But to some a theory which supposes everything to be energy seems insufficient to account for the fact that bodies are hard and solid and actually occupy space. They ask, "If there be no material entity and if energy in motion be the only *stuff* of which the world

is made, how comes this property of extension? How can energy fill space?"

No entirely satisfactory answer has yet been found, but the electron theory hints at a solution. The electron or corpuscle is a disembodied unit charge of negative electricity. It is thought that this electricity does not occur in the form of a geometrical solid of definite size and with definite boundaries. Rather it is believed that the electrical energy of which the electron is composed is distributed through space, extending infinitely in all directions. Thus, as J. J. Thompson says, "each corpuscle may be said to extend throughout the universe."[11] Actually, then, the electron more truly "occupies space" than did the old hypothetical material entity, for the "extension" of an electron is infinite.

But if this be true, as it is, beyond reasonable doubt, then every electron interpenetrates every other electron, which appears to be a direct contradiction of the law of the impenetrability of matter. This apparent contradiction can, however, be reconciled in a manner which throws much light upon the problem of extension.

While every electron extends throughout the universe, yet by far the greater part of the electrical energy of which it is composed is concentrated in a very small space about a point. This sphere of great concentration is exceedingly small, its radius being about 10^{-13} cm.[12] Outside this volume of great concentration, the amount of electrical force is negligible. Hence the mutual repulsion of electrons is appreciable only when the distances between their centers is very small. But when their proximity is exceedingly close, as in an atom composed of several electrons, then the force of repulsion is very great. Thus, while it is true that in an atom of one electron the mutual attraction between the nucleus and the electron pulls their centers together until they are at the same point, yet in an atom of more than one electron, the centers of the several electrons, when they come close together about the nucleus, will exert a great repulsion upon each other, with the result that they will *not* come together with their centers at the center of the nucleus but will, instead, group themselves about this center. At equilibrium the electrons will be ranged in a spherical surface with the center of the nucleus as its center, or, if the number be large, in several such spherical surfaces, one within the other.

Now such a system of electrons, held in their positions about the nucleus by such powerful forces would very plainly resist any attempt to distort its shape. Although it might take up additional electrons or give off extra electrons, thereby changing its constitution and hence its structure, yet any attempt to distort its structure without so changing its constitution would be powerfully resisted. Consequently the atom would be practically impenetrable.

Now, atoms which lack their full quota of electrons attract atoms which have more than their full quota. Because of these mutual attractions, atoms come together and build up molecules. But here too the forces of repulsion prevent the atoms from actually coinciding with each other, so that the molecule is larger than the separate atoms of which it is composed. The molecule is thus a system of atoms which is usually simple but sometimes, as in the proteins, exceedingly complex. The molecule is of course susceptible to forces tending to bring about a change in its constitution. But any effort to change its form without changing its constitution is powerfully resisted, just as in the atom. Hence the molecule, too, is practically impenetrable.

Now intermolecular forces attract molecules together. If a sufficiently large number of molecules are brought together, a body of appreciable size is formed, one which can be directly perceived by the senses. The molecules may thus be so strongly held together that their relative positions can be changed only with great difficulty. According as this difficulty is of one kind or another, we say that the body is hard, or has great tensile strength or offers a great resistance to shear stresses or to compression. In other cases, as of gases, the intermolecular forces seem to be small, and such substances offer very little resistance to a change of form. Thus bodies of appreciable size while offering some resistance to a penetrative force, are not always "impenetrable", in fact never so in that sense of "impenetrable" which means impossible of penetration.

It has been shown, however, by the preceding discussion of electrons, atoms and molecules, that the *stuff* of which bodies are made is impenetrable in the sense that no two molecules or atoms will occupy the same space at the same time. Thus we have an explanation of the "impenetrability of matter" in terms of the electron theory.

The above discussion of the property of extension shows that impenetrability of matter, which is the empirical basis for the idea of extension, is an outcome of the play of attractive and repulsive forces, and is therefore a derivative of energy. These considerations show further that if an "absolute extension", other than the one based upon impenetrability, be insisted upon, then electrons or structures built of electrons possess this property of extension in an infinite degree, for an electron extends throughout the universe. We can therefore conclude that *no hypothesis of a material entity is necessary to account for extension*, because *energy itself*, when organized in electrons, atoms and molecules, *possesses* this property of *extension*.

The whole of the foregoing discussion of matter and its constitution has shown that a theory which supposes matter to be but a form of organized energy is sufficient to account for all the phenomena of matter

which we have considered, including the properties of extension and mass. In fact, this theory can not only be reconciled with all known phenomena but it also gives a more simple and comprehensive explanation than any other theory and, what is perhaps most valuable of all, it explains many phenomena which were hitherto inexplicable. For these reasons the scientific world is accepting the electron theory of matter.

With an insight illuminated and clarified by this hypothesis we realize now the intricacy and complexity of the inner constitution of the atom and the enormous forces locked within it. But this discovery has thus far failed of any great *practical* application. The forces in the atom are not available for human use. Man has thus far been unable to unlock this enormous store of energy. And yet, even though there have been no direct utilitarian results, this electron theory has given us a means by which to solve many of the knotty problems of science. It has illuminated the whole field of natural phenomena and has thus increased our mastery of the world.

This theory has also shed much light upon philosophy in that it has aided us to a truer understanding of the universe. For now we see, with clearer light than before, the weakness and folly of a materialistic philosophy. We know now that *matter* is not an ultimate entity.

If we revert now to the early part of this discussion, we shall find that it began as an inquiry into the nature of reality. We have inquired more particularly into the nature of that phase of reality commonly known as matter. We have questioned the metaphysical assumption of a material entity. We have suggested that the need for this material entity is a psychological one, arising from the tendency of unreflective thought to seize upon the persistent and universal properties of extension and mass as indications of a substance or matter which lies back of and gives support to the less persistent properties. We have taken up at great length a consideration of mass and extension and have found that, far from being primordial and original properties of a material entity, they are instead derivatives of two most non-material things, energy and motion.

We have thus, by a course of scientific reasoning, come to the conclusion that this is not a universe of dead atoms propelled by blind force but a universe of active energy.

It seems to the writer that in this conclusion lies the possibility of a definite, thorough and complete reconciliation of Science, Theology and Philosophy. It is unfortunately true that in some cases the very opposite has happened. Scientists brazenly declare that by means of this theory they have invaded the camp of theology and have stolen its very holy of holies. Theologs loudly declaim that Science, in accepting

this hypothesis, has destroyed its own foundation and has given up its materialism for a God; while Philosophers have taken this latest revolution in thought as evidence of the lack of reliability and security in all our knowledge. Such is the attitude of some of our more radical and over-enthusiastic Scientists, Theologs and Philosophers. But the student of Science who combines with his study some measure of devotion and contemplation; the devotee of Religion who tempers his spiritual emotion with logic and deep thought; the seeker after a true Philosophy who holds himself close to empirical knowledge and yet gives his emotions a rightful place,—all these, I believe, can find in this new conception of a universe of active energy a more logical and comprehensive rationality, a deeper and richer spiritual meaning, and a grander and nobler plan. Thus may all partial views be wrought into a truer and more complete understanding of the universe as being, all in one, logical, purposeful and sublime.

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(5) Thompson, p. 103.
(6) Rutherford, pp. 129-130.
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(8) Duff-McClung, pp. 506-510.
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(10) Rutherford, p. 124 (½ period of RaC_1 and RaC_2 as given in Duff-McClung, p. 518.)
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LEARNING THE FIRST-MAGNITUDE STARS.

FREDERIC CAMPBELL, Sc. D.*

One stands bewildered and confounded before the 8,000 stars visible to the naked eye, the 100 million visible through the best refractors, and the million million visible by the aid of photography. To know the stars is indeed a gigantic task, nay, an impossible one. But the fact that we can never hope to know them all, nor even a considerable fraction of them, need not militate against our knowing some of them. And those which seem to stand foremost in their appeal are the few that appear brightest as seen from the earth, the first-magnitude stars, only twenty in number. The minimum task for one to set himself, who purposes to know the stars, consists of the facts concerning this single score of luminaries.

It is encouraging at the outset, to us of the northern hemisphere, to reflect that these twenty are reduced to fifteen, by eliminating the five stars seen only in the south, and never visible to the great majority of mankind. Still, these five being principal stars, one of them Canopus, which stands second in the entire list, it ought not to be thought impossible to include them in those to be learned. Now it is something to know just the names of these twenty brightest stars; it is more to know their names in their proper order, namely that of brilliancy, and thus to know the rank of each. Who could not accomplish at least this much, if he cares to accomplish anything?

But there are at least three other points to be added with each of these stars, namely, first, their distance, expressed in light-years, second, their inherent brilliancy, expressed in terms of our own sun as unity, and third the percentage of light received from them, on the basis of Sirius, the brightest, considered as 100 per cent. Those who are willing to enlarge the task by adding yet two points, will do well so to do, namely, the magnitude of each star expressed in units and decimals, and the motion of each star in miles per second, toward or from the earth.

These last two points the writer has omitted in his own endeavor, and has confined himself to these others: (1) each star's rank; (2)

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name in order; (3) distance; (4) brilliancy in itself; (5) percentage of Sirius. Here then are five things which he determined to know of each of twenty stars, or 100 points in all. To this he later added the relative distance from the earth, as applied to four stars, the positions of the others being unknown.

In order to simplify the task, he took the first half first; and, when these had become familiarized, he advanced to the second half. These had to be recited over and over, with occasional reference to the table to correct mistakes and refresh memory. But this proved to be no great task, inasmuch as there are not a few spare moments in the day when one may run over his lesson. Thus, in various physical exercises which I take, I made it a rule not merely to count what I was doing, but to make the count a rehearsal of the first-magnitude stars, with the facts concerning them. Nothing but such persistence will keep these 104 facts fixed in mind; many of them will slip away, except for constant reiteration.

To illustrate, I give my five points for each star in this fashion: "One, Sirius, 8.7 light-years distant, 48 suns, 100 per cent. Two, Canopus, 466 light-years distant, 55,000+ suns, 52 per cent. Three, Alpha Centauri, 4.3 light-years distant, 2 suns, 21 per cent." And so on. To this I however became accustomed to add the relative distance of the four mentioned, so that, when I pronounce "Sirius", I also say, "third distant;" or "Alpha Centauri, nearest;" or "Procyon, sixth distant;" or "Altair, twelfth distant." This adds but little and is important to know definitely.

Now, while nothing but persistent resolution will accomplish this task and keep it accomplished, there are certain "mnemonics," or aids to memory, which anyone can discover or devise for his help. While some of these may seem foolish and far-fetched, they nevertheless do the work. These aids are rooted in the psychological principle of "the association of ideas." Thus, when I take up Canopus, I associate in my mind the 55 of the 55,000+ suns, with the 52 per cent of light received. The distance of Alpha Centauri is observed to be practically half of that of Sirius. Arcturus' figures of 43 and 230 are easily linked. Rigel, like Canopus, being 466 light-years distant, its 22,000+ suns are readily suggested by the 55,000+ of Canopus. In the case of Procyon we have the 6th distant star, 8th in rank, 10 light-years distant and 10 suns, giving 15 per cent of light, which supplies us with the following progression of figures, 6, 8, 10, 10, 15. Altair is 12 light-years distant and gives the light of 12 suns; it also is 10th in rank and gives 10 per cent of Sirius' light. Other aids can be found or invented through the second half of the table.

It proves to be a great satisfaction, in viewing, dealing with, or speak-

ing of, any of the first-magnitude stars, not to be obliged to refer to the table, but simply to recall the facts from memory. The process of acquiring and of retaining these facts is also of unquestionable value in the discipline of the mind and the cultivation of memory. One should not stop however with a mere tabular knowledse of the first-magnitude stars, but should know the constellations in which they are found, and be able instantly to point them out. He who knows even this much about the heavens can never be accused of ignorance of Astronomy.

TABLE OF FIRST-MAGNITUDE STARS.

PREPARED BY FREDERIC CAMPBELL, SC. D.

Rank	Name	Mag.	Light Received	Distance in Light-years	Brilliancy times sun	Approach,(−) Recession,(+) Miles per sec.
1.	Sirius[3]	−1.6	100 ⅘	8.7	48	− 5
2.	*Canopus	−0.9	52	466	55,000+	+12.4
3.	*Alpha Centauri[1]	0.1	21	4.3	2	−13.7
4.	Vega	0.1	21	35	160	− 9.3
5.	Capella	0.2	19	50	300	+18.6
6.	Arcturus	0.2	19	43	230	− 3.1
7.	Rigel	0.3	18	466	22,000+	0
8.	Procyon[6]	0.5	15	10	10	− 2.5
9.	*Achernar	0.6	13	64	350	
10.	Altair[1½]	0.9	10	14	12	−20.5
11.	Betelgeuse	0.9	10	109	1,400	−17.5
12.	*Beta Centauri	0.9	10	88	277	0
13.	*Alpha Crucis	1.1	8	59	207	0
14.	Aldebaran	1.1	8	45	110	+34.2
15.	Spica	1.2	8	500+	12,900+	+ 1.2
16.	Pollux	1.2	8	50	125	+ 1.9
17.	Antares	1.2	8	112	630	− 1.9
18.	Fomalhaut	1.3	7	23	25	
19.	Deneb	1.3	7	500+	11,250+	−36
20.	Regulus	1.3	7	99	420	+23

* Southern stars, invisible in northern latitudes.

Note:—Small figures, attached to stars, indicate their relative distance from the earth.

Beaver Falls, N. Y.

SOME SOUTHERN DOUBLE STARS.

BERNARD THOMAS

The southern sky is particularly rich in celestial objects, many of which are within easy reach of quite small telescopes. With a two-inch refractor I have been able to identify over five hundred double stars. Some of these however would no doubt be considered rather wide, being over 30″ separation, but on the other hand many were as close as 5″ and some few 3½″ or under. This however would by no means exhaust the possibilities of a very small instrument, as I was constantly finding some new object; but lately I have been using a reflector of eight inches clear aperture which considerably augments my view point. As double star observation is most fascinating and as, unfortunately, information about the more familiar southern objects is difficult to obtain, a short account of some few of the more prominent, brilliant and easily identified celestial jewels may be of interest to southern readers of POPULAR ASTRONOMY.

The material for this account is largely collected from "The Reference Catalogue of Southern Double Stars", an expensive and rare work, and from other more recent sources where available.

β Toucanae. $0^h\ 27.0^m$, $-\ 63°\ 31'$. Magnitude as single star 3.6. Components β^2 mag. 4.33. S. M. P. β^1 mag. 4.50 S. M. P.

4.3. 4.5; 170°.7; 27″.2 Innes 1901.5. This measure places β^1 brighter than β^2, but really there is very little difference between the two stars. In the Reference Catalogue β^2 is said to be a yellowish star and β^1 white or bluish. To me however there does not seem to be any marked contrast; both appear bluish white, as is also the fifth magnitude star 54 (U. A.) Toucanæ, which makes a fine naked eye double. The earliest measures of Sir John Herschel's in 1835 are practically identical (352°.3; 27″.76), and all subsequent measures, of which there are several in the Reference Catalogue, confirm the absence of any change. The common proper motion is fairly large, 0″.103 to 132°.8. It is however really a ternary system, as β^2, whose spectral type is A2, is a close binary (4.6, 6.8; 268°.7; 0″.67. 1913). The wide pair must therefore be considered fixed and is a splendid example of this strange law which appears to be the rule that so many doubles conform to. This is a well known object for small telescopes and the brightness of the components and the other bright stars in the field make it an excellent picture for a low power field.

β Phoenicis. $1^h\ 1^m.6$, $-47°\ 15'$. Magnitude 3.35. Spectrum K (like most of the bright stars of this constellation α, γ, δ etc.). Has a proper motion of 0″.062 to 256°.9. 4.1, 4.2; 10°.6; 1″.28. 1913. (18°.1; 1″.45 1900). A binary system with retrograde motion of about 1° per annum since discovery. Herschel noted an 11^m companion at 17.°6; 30″, but failed to detect the duplicity of the chief star, which was discovered by Sellors in 1892 (26°.3; 0″.93).

This is a wonderful object in the eight-inch reflector; both stars are a deep yellow and easily separated with a power of 160. I do not know that any orbit has been computed but it may be of about 300 years period.

γ *Volantis.* $7^h\ 9^m.6$, $-70°\ 20'$. Magnitude 3.70. Spectra K and G. Common p. m. of 0″.097 to 15°.0 and radial velocity of 2.3 kms.

3.9, 5.7; 299°.7; 13″.3. Tebbutt 1888.3. This, like β Toucanæ, seems another example of the fixed type. The early measures differ so slightly from this that we can be assured of its fixity. The great interest of this object is the beautful contrast of colors usually observed in a small instrument. In the refractor I noted them rich yellow, slightly orange (golden) and blue, purple or violet; the color of the small star seemed to vary with atmospheric conditions. In the reflector however, although I have noticed this contrast on some nights, on others with a power of about 160 both seem yellow, the brighter star the more orange of the two.

Considering that the primary is of "late" solar type, it is to be noted that both proper motion and radial velocity are relatively low. It almost seems as if this system were journeying nearly in the same track as the Sun but at a slightly faster rate, a member of the solar cluster. If this be the case the small proper motion might be accounted for as not due to great distance.

υ *Argus.* $9^h\ 44^m.6$ — $64°\ 37'$. Magnitude 3.08. Proper motion only 0″.027 to 293°.7. Pale orange star. 3.1, 7.0; 128°.6; 4″.99 (1911). Fixed. For Herschel's measures are nearly identical. Comes a distinct blue.

I found this object fairly easy with the little refractor if atmospheric conditions were good with a power of about 68. But to see it to better advantage in the reflector a medium eyepiece can be used. In the field about 6′ s f, is a little double of eighth magnitude stars (McKay of Melbourne, 8, 8, 315°, 6″ est.). I think the distance of these two little stars is probably wider now.

θ *Eridani.* $2^h\ 54^m.5$, $-40°\ 42'$. Magnitude. 3.06. Spectrum A2. Common proper motion 0″.085 to 290°.6.

3.40, 4.49; 84°.9; 8″.17, Lunt 1900.8. Here it seems that there has been a slight increase in angle since Herschel measured in 1835 (81°.5; 8″.71) and the measures show this consistently. The measures of Jacob

1845-1857 and Russell 1874 also show a diminution in the distance and, Innes says, suggests the inevitable disturbing body. It is of interest to note that the larger star is a spectroscopic binary. I suppose we can regard the pair as probably a binary system of extremely long period.

Another interesting point is that Theta Eridani is suspected to have decreased in magnitude from the first in the tenth century, according to the estimation of Al Sufi, whose magnitude determinations are usually remarkably reliable (Gore).

A wonderful telescopic object; one of the finest southern doubles for small telescopes. I noted colours in the two-inch as bluish white and yellowish white, in the reflector white and blue.

γ *Centauri.* $12^h\ 36^m.0$, $-48°\ 25'$. Magnitude 2.38. Spectrum A0. Proper motion $0''.201$ to $265°.7$. This is very similar to τ Centauri. Magnitude 4.02; spectrum A2; p. m. $0''.199$ to $264°.5$ a star near. There is a small star *w* Centauri, magnitude 4.7, at $45°.7$ and $760''$ from γ, with which it makes a naked eye double.

This bright star is a brilliant binary, beyond the reach of small telescopes, but easily divided by the reflector (3.1, 3.1; $348°.1$; $1''.13$ 1913). At present Professor See finds a period of 88 years with a semiaxis major of $1''.02$, periastron in 1848, and retrograde motion.

This brilliant object is best seen in twilight or moonlight when the glare is lessened by the light field.

β *Muscae.* $12^h\ 40^m.2$, $-67°\ 34'$. Magnitude 326. Spectrum B2. Proper motion, $0''.058$ to $256°.0$. Another binary system but probably of much longer period than the former system. At present an easy object in my reflector: 4, 4; $351°.2$; $1''.52$ (1912.) Colours greenish white. A power of 100 diameters will separate this object on a clear night. Russel's measures in 1880 are $317°.3$; $0''.54$. The angle has increased 34° in about 32 years, so possibly the period may be about three hundred years.

μ *Lupus.* $15^h\ 11^m.6$, $-47°\ 30'$. Magnitude 4.36. Spectrum B8. Common proper motion of $0''.095$ to $212°$.

4.6, 6.9; $130°.2$; $23''.4$. See 1897.1. Fixed. In a wonderful field with 9^m, $108''$ s. p., and other stars. Colours white and violet. The bright star of this double is a binary system: 5.1, 5.3; $153°.6$; $1''.91$ (1913); $173°.5$; $2''.08$ (1836) but evidently in very slow motion. All three are of course easy in the Reflector. The constellation Lupus offers many objects of this class of double stars some of which are binary with a similar spectrum of the Orion class: κ, γ, ϵ, θ, π and others.

α *Centauri.* $14^h\ 32^m.8$, $-60°\ 25'$. Magnitude 0.06, as a single star. Components: 0.33 α^2, spectrum G and 1.70 α^1, spectrum K. The finest binary (with the exception of Sirius whose *comes* is too minute for ordinary telescopes) in the whole heavens. The latest measures I have

are 218°.1; 17″.53 (1914). The components are now apparently approaching each other. In the early years of the present century the distance was nearly 22″.

The period of this beautiful pair seems to be about 81 years. The great interest of this binary is of course its nearness to us, with a parallax of 0″.75 (four and a quarter light years), the similarity of its components to that of our Sun in mass (1.04 and 0.90) and probably in size. As a telescopic object it is at present within the reach of any small instrument and in the larger apertures is a wonderful sight which even those who are ignorant of astronomy can hardly fail to admire. The colours are yellow and deep yellow blazing in the field with a few fainter stars.

α *Crucis*. $12^h\ 21^m.0$, − 62° 36′. Magnitude 1.05. Spectra both B1. Common proper motion of 0″.045 to 242°.

The two principal components of this brilliant system are α^1, magnitude 1.58, and α^2, magnitude 2.11, with a third star of about the sixth magnitude. The following are the latest measures available:

AB	1.6,	2.1;	118°.0; 4″.74	1901 Cape.
AC		6.	202°.2; 90″	1858.

The various measures do not indicate much angular change in AB, though the distance in Herschel's measure of 1835 is greater. The little star Lac. 5147 shows no signs of change. Here we have a notable instance of fixity in this most brilliant triple.

Alpha Crucis is the second brightest double star in the whole heavens and comes next to Alpha Centauri. The components of Castor are not so bright though it much resembles this system in appearance, the little ninth magnitude star in the former taking the place of the yellow sixth magnitude and also sharing in the proper motion of the bright double, but Castor is a binary and so here the resemblance ends. The colour of the bright stars in α Crucis seems always pure white to me, the fainter star being decidedly yellow. There are several other stars in the field, of seventh magnitude and fainter.

Dr. Gill found a relative parallax of 0″.05 for this pair, which would make the minimum distance between the components about 100 times that which separates us from the Sun. The absolute parallax will be greater. Yet there is no trace of any orbit, a fact perhaps in part accounted for by the probably low density of this type of star.

Glenorchy, Tasmania.

VEGA LYRAE.

CHARLES NEVERS HOLMES.

Alone—unrivalled—'midst its jewelled Lyre
A sun of summer crowns the starry sky,
And in the splendor of its sparkling fire
Surveys our world like blue and brilliant eye;
'Mid night's long watches it doth never tire
When men and women wrapped in slumber lie.
Through peace or war, in death or danger dire,
It shines the same as youth and years roll by.

Vega!—blue, brilliant, beautiful Vega! August has come, the dog-day reigns, nights are warm and the stars seem to twinkle drowsily amid the darkened firmament. Nine o'clock has just been announced by some village church-bell, and "the last steps of day", a glorious sunset, have slowly disappeared in the west. All the summer suns of night are once more sparkling with greater or less brilliance. In the northwest glitter the seven noticeable gems of Ursa Major, turning around the almost immovable pivot—Polaris. In the southwest there glows the ruddy fire of Antares amid the weird constellation of Scorpio. Rising towards its September height at the zenith sparkles the five-starred Cross of Cygnus, while not far away there shines the sun Altair in Aquila. And still nearer the Cross of Cygnus, high overhead, like some fiery firmamental jewel, scintillates Vega—blue, brilliant, beautiful Vega!

Vega Lyrae—Vega of the constellation Lyra. Lyra or the Harp is not at all a noticeable star-group with the exception of brilliant Vega. However, besides Vega, the Harp possesses other stars, although none of them is conspicuous to the unassisted sight. Of these lesser stars, Beta, Gamma and Epsilon are more easily seen, Beta and Gamma being also called respectively Sheliak and Sulaphat. Of these three stars, Beta is a variable sun, its magnitude varying from 3.4 to 4.1; it is also a triple star when using a 3-inch glass, or a double star through a 2-inch. Epsilon is a remarkable "Double Double" sun, that is, it is a double sun through an opera-glass while a telescope of 3 or 4 inches will reveal that each of these double suns is itself a double star. There are also the stars Eta, Zeta and Delta, all of which are doubles; but the constellation Lyra is chiefly interesting, without a telescope, because of its blue and sparkling *brilliant*—beautiful Vega.

The first-magnitude sun Vega, also written Wega, must have received considerable attention from the simple-minded star-gazers of prehistoric times. It was certainly mentioned both by the citizens of Greece and Rome, as well as by the Chinese, Egyptians and other ancient peoples. As is well known, Vega will be our northern pole-star around about the year 14,000 A. D., taking the firmamental place of Polaris. Vega is also interesting because the voyage of our Sun and solar system through the boundless ocean of space is carrying us in the general direction of this brilliant star. Gazing at blue Vega with our unassisted sight we should hardly know that it possesses a companion sun. Of course the brightness of Alpha Lyrae tends to hide the presence of this other sun from discovery; but we are able to find it with a 4 or 5 inch telescope. The respective magnitudes of Vega and its companion are 0.1 and 10. With respect to Vega itself, this splendid sun is approaching our solar system with a velocity of about 10 miles per second; at present it is approximately 35 light-years distant from us.

But to most people of this generation Vega is far more interesting popularly than from a scientific standpoint. Viewed by unassisted sight as it sparkles and scintillates so brightly at the very zenith, Alpha Lyrae is certainly firmamentally spectacular. Even an inexperienced star-gazer can easily find this sun and then recognize a little of the terrific power expressed by the distant glitter of this glorious sky-jewel. Truly this star seems all alone and unrivalled, and indeed although Sirius of Canis Major is incomparable during the winter season in his fire and splendor, Vega of Lyra is the queen-sun of our summer evenings. Although there is only one Sirius there is only one Vega—blue, brilliant and beautiful Vega!

Newton, Mass., 41 Arlington St.

THE METEOR OF FEBRUARY 5, 1917.

EDWIN B. FROST.

On the evening of Monday, February 5, 1917, a brilliant meteor passed over northeastern Illinois and southeastern Wisconsin. This was on the night preceding full moon. The sky was clear at this observatory. The meteor must have been a brilliant one, because the illumination it produced was so bright as to be seen by many persons in this vicinity through their windows while they were reading under electric

lights. It was thought by many persons to have been a flash of lightning, and some supposed that thunder was heard after the flash. No member of the Staff observed the meteor in the sky, but Mr. Sullivan, who was guiding with the spectrograph at the time, with his back toward the opened slit of the dome, saw the flash on the floor and supposed that it was from the headlight of some automobile.

The estimates of the time at which the meteor passed are discordant, but as given by a young woman at the telephone exchange, who associated the time with the close of her period of duty, it would seem to have been between 8:23 and 8:25 C. S. T. It may have been a few minutes later, however.

An entirely false rumor was circulated in some papers that the meteor fell near the observatory, and a number of persons traveled considerable distances in the hope of seeing it.

The noise of the meteor was heard, according to the reports, by persons over a wide region, and its light was seen by so many persons that it seemed worth while to try to get data from eye-witnesses. Accordingly on February 8, I sent out a circular letter to the principals of many of the schools as far east as Waukegan, Illinois, and as far west as Rockford, Illinois and Janesville, Wisconsin. As is usual under such circumstances, the reports thus obtained are more or less contradictory. As nearly as can be made out, the meteor came from over Lake Michigan, moving in a northwesterly direction, and passed over a point somewhere between Chicago and Waukegan, perhaps somewhere near Winnetka. At that point in its flight, it was observed as far north as Bristol, Wisconsin, and as far south as Elmhurst, Illinois. It appears to have passed between 6 and 10 miles south of the Yerkes Observatory, having been observed to be south of the zenith at Zenda, Wisconsin, and north at Harvard, Illinois. It was seen by several observers at Milton and Milton Junction, and finally, so far as these reports go, was last observed by a man walking on the highway a mile and a half east of Janesville, Wisconsin, who saw it break into four pieces. He states that there was no sound, as he and his companion stood looking, but there was quite a jar of the earth about 3^m after it burst. He added that the tail was very long, was of a bright red color. He estimates the altitude at which it burst at about 30° above the southwestern horizon.

Either direct sounds, or a rumble, or jar of the earth, have been reported from all points along the flight above described, but there is some contradiction as to the interval between the flash and the sound. Thus a man at Spring Prairie, about 7 miles northeast of Lake Geneva City, left his house, after glancing at the clock, between 8:25 and 8:30, and walked north, when the ground was lighted up all at once in front of him; when he had walked about 30 or 40 rods farther, he heard a

distinct rumbling. But a woman at Milton Junction, Wisconsin, stated that "it exploded in the air about 50 feet from the ground about 30 rods from my house, making a report like a 16 gage shotgun. The meteor was the size of a quart bowl, color bright red, tail about 10 feet long. It came direct from the east at 8:30 p. m." In reply to a later question, she stated that the report followed the bursting so quickly that she supposed her husband had fired his gun in the vicinity.

It would seem that there were explosions of the meteor at more than one point, as the position in the sky at which explosions were reported can only be reconciled on this basis. An explosion was reported from a point not far from Lake Michigan, and again near Zenda, which is about 8 miles southeast of this observatory, and finally again southwest of Janesville. Two observers at Milton, who saw the explosion, give the azimuth in such a way as to be consistent with the observation at Zenda, but not with that at Janesville. Several of the observers state that the meteor turned red and burst. An observer at Bristol, Wisconsin, not far from Lake Michigan, stated that it left a tail like a comet with sparks flying on either side.

None of the reports locate the object with respect to the stars, and the statements as a whole are insufficient to make it worth while to attempt to compute the true path of the meteor. It is interesting to note, however, that this apparently was the object reported by Mr. Truman in the February number of POPULAR ASTRONOMY. From the azimuth he gives, it would seem that he observed the meteor when it was over Lake Michigan, or just as it came over the land, at a distance of about 200 miles. His azimuth would have been very different if he had seen it travel as far as Janesville.

Communications addressed to the principals of schools in some of the towns in Wisconsin northwest of Janesville have not been answered, so that it may be possible that we shall secure no additional information.

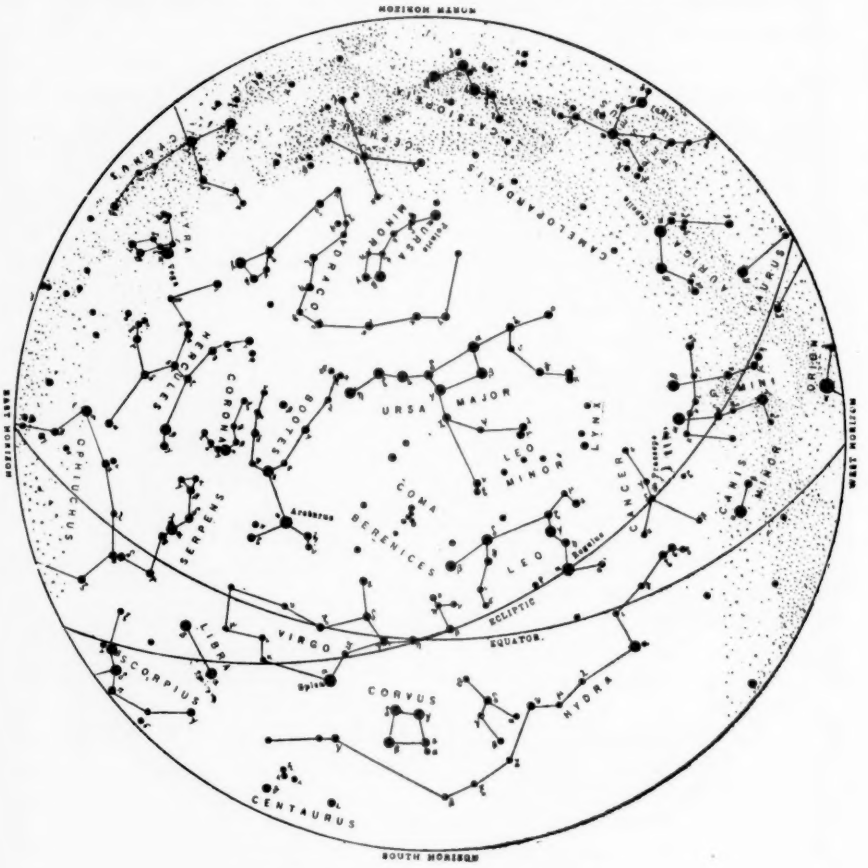
In this statement no attention has been paid to reports in newspapers, but only to those of actual witnesses of the phenomenon.

Yerkes Observatory, Williams Bay, Wis.

March 20, 1917.

PLANET NOTES FOR MAY, 1917.

The sun will move during the month by a northeasterly course from Aries into Taurus. About the middle of the month it will be near the region of the Pleiades.



THE CONSTELLATIONS AT 9:00 P. M. MAY 1.

The phases of the moon for May are as follows:

Full Moon	May	6	at 9 A.M.	C.S.T.
Last Quarter		13	" 8 A.M.	"
New Moon		20	" 3 A.M.	"
First Quarter		28	" 2 A.M.	"

Mercury may be seen in the evening twilight during the first week of the month. On May 7 it sets about 50 minutes after sunset. It will be found in the

constellation Taurus near the Pleiades. Its stellar magnitude is about —0.1. During the month it will move with a retrograde motion.

Venus will be an evening star after May 23. On this date it will be found 6° north of Aldebaran; its magnitude will be —3.4, and the ratio of the illuminated portion of the apparent disc to the area of the entire apparent disc regarded as circular, 0.992. The planet will move from the constellation of Aries into the constellation of Taurus and will be found in the eastern portion of the latter constellation at the end of the month.

Mars will not be visible during the month.

Jupiter will not be visible during the month.

Saturn will be visible in the western sky during the entire month. It will be found in the constellation of Gemini.

Uranus may be seen with the aid of a telescope in the morning sky in the constellation of Capricornus.

Neptune will be in the evening sky during the month. It is quite faint, +7.7 magnitude, and cannot be seen without the aid of a telescope.

Occultations Visible at Washington.

[*From the American Ephemeris*].

Date 1917	Star's Name	Magnitude	IMMERSION. Washington M.T.		Angle f'm N.	EMERSION. Washington M.T.		Angle f'm N.	Duration	
			h	m	°	h	m	°	h	m
May 7	31 B Scorpii	5.4	9	32	119	10	43	277	0	51
7	40 B Scorpii	5.4	12	12	113	13	36	272	1	11
7	50 B Scorpii	6.4	15	33	45	16	24	319	1	23
10	191 B Sagittarii	6.5	15	32	90	16	49	233	0	51
30	64 B Virginis	6.5	13	5	136	14	0	267	1	17

Variability of Uranus.—In order to determine any changes which might take place in the light of the Sun, Mr. Leon Campbell undertook a series of photometric observations of the light of Uranus. This led to the discovery that the light of this planet varies by about 0.15 magn. in a period of $0^d.451$. The results of these measures are shown in Fig. 1. The photometer employed was that having achromatic prisms and described in H. A. 69, 3. The total number of settings was 2960, divided into 185 sets of 16 settings each.

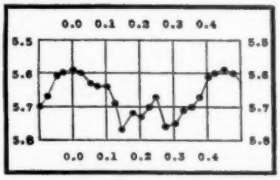


FIG. 1.

It is interesting to note that the period agrees with that of rotation found by Professor Lowell and Dr. Slipher (Lowell Observatory Bulletin, 53). The latter determination was made with the spectroscope, and the photometric value was deduced entirely independently. We may, therefore, conclude that the variation in light is due to unequal brightness of different portions of the planet, and that by later photometric measures the period can be determined with a high degree of accuracy, if the variations in brightness are permanent.

Harvard College Observatory. Circular 200. EDWARD C. PICKERING.
January 25, 1917.

VARIABLE STARS.

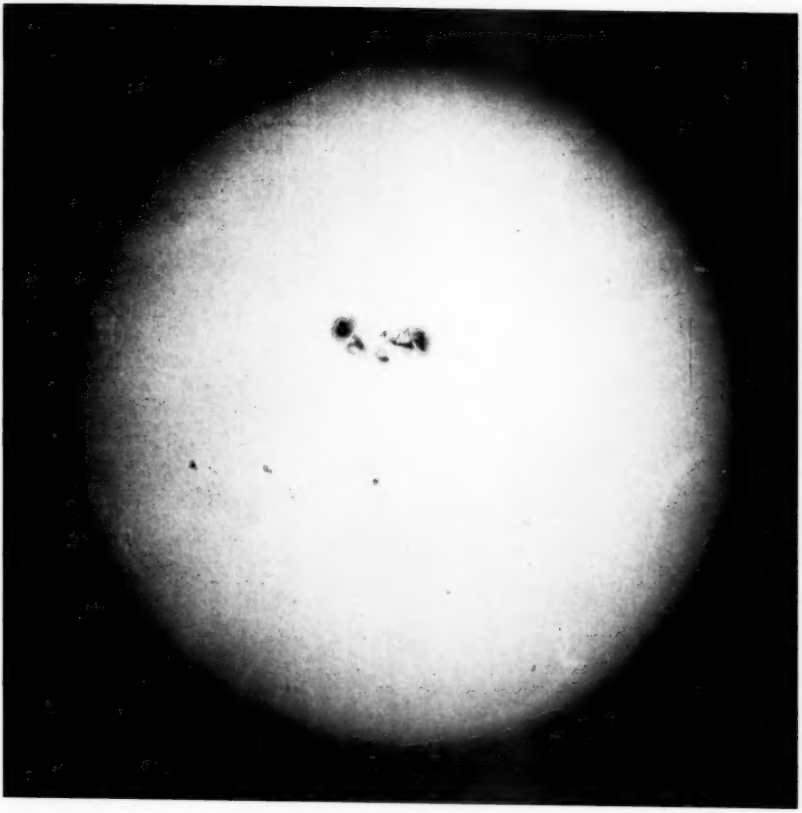
Minima of Variable Stars of Short Period.

[Calculated by Lois N. Wilson at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1917 May							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8	8 2							
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	7 6;	14 23;	22 15;	30 7				
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	1 20;	9 6;	24 3;	31 14				
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	7 21;	15 8;	22 20;	30 7				
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	3 9;	9 12;	21 17;	27 20				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	5 18;	12 22;	20 1;	27 5				
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	4 9;	18 3;	24 23;	31 20				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	3 8;	10 13;	17 17;	24 21				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	3 23;	12 18;	21 12;	30 7				
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	6 19;	14 18;	22 16;	30 15				
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6	7 16							
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	3 13;	9 6;	20 17;	26 11				
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	6 8;	13 4;	19 23;	26 18				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	7 15;	15 12;	23 10;	31 8				
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	5 13;	13 20;	22 4;	30 11				
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	4 0;	11 21;	19 18;	27 16				
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	2 5;	15 9;	28 14					
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	4 1;	13 12;	22 22					
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	1 21;	14 7;	26 17					
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	2 13;	9 5;	22 13;	29 5				
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	5 13;	13 17;	21 21;	30 2				
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	3 2;	9 2;	21 3;	27 4				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	3 23;	12 15;	21 9;	29 13				
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	7 0;	17 10;	27 19					
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	6 4;	14 4;	22 5;	30 5				
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	5 10;	11 4;	22 15;	28 8				
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	2 19;	14 0;	25 5;	30 19				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	8 18;	16 23;	25 4					
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	6 13;	14 4;	21 19;	29 10				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	2 17;	14 22;	27 3					
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	1 14;	8 18;	23 3;	30 7				
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	4 15;	11 10;	25 1;	31 21				
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	5 5;	14 12;	23 19					
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	1 15;	8 6;	21 11;	28 2				
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	3 0;	11 10;	19 20;	28 5				
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	6 13;	12 23;	19 10;	25 10				
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	6 11;	13 17;	20 0;	28 6				
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	5 13;	13 16;	21 19;	29 22				
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	5 13;	15 1;	24 12					
RX Hydrae	9 00.8	− 7 52	9.1—10.5	2 6.8	3 19;	10 15;	24 8;	31 4				
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	3 7;	9 5;	21 2;	27 0				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	3 17;	10 11;	23 23;	30 17				
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	3 6;	10 16;	18 2;	25 12				
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	7 4;	13 18;	20 8;	26 23				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	4 0;	12 19;	21 14;	30 10				
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	5 10;	12 18;	20 2;	27 10				
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	5 14;	12 9;	19 4;	25 23				
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	8 0;	15 12;	23 0;	30 12				
RS Can. Ven.	13 06.3	+36 28	7.5—12.5	4 19.2	3 22;	13 12;	23 2					
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	3 20;	11 7;	18 17;	26 4				
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	2 4;	9 4;	23 3;	30 3				

PLATE X



SUNSPOT OF FEBRUARY 9, 1917.

Taken by Miss Mary R. Calvert with the 12-inch Yerkes Telescope, stopped down to 1½ inch.

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1917 May
	h m	° ′		d h	d h d h d h d h d h
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	4 6; 11 4; 24 23; 31 20
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.4	8 14; 16 0; 24 10
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	5 2; 12 18; 20 10; 28 2
SW Ophiuchi	16 11.1	− 6 44	9.2—10.0	2 10.7	6 15; 13 23; 21 7; 28 15
SX Ophiuchi	12.6	− 6 25	10.5—11.2	2 01.5	9 3; 17 9; 25 15
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	4 5; 13 1; 21 22; 30 18
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	11 11; 21 4; 30 6
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	3 11; 10 7; 23 21; 30 16
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	8 22; 17 7; 25 17
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	3 5; 9 9; 21 16; 27 20
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	4 16; 11 22; 19 3; 26 7
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	1 1; 8 10; 23 4; 30 13
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	1 9; 9 13; 17 17; 25 22
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	2 18; 10 7; 17 20; 25 9
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	8 3; 15 21; 23 15; 31 9
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	6 8; 14 8; 22 8; 30 7
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	4 3; 12 15; 21 4; 29 16
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	9 2; 18 20; 27 18
SX Draconis	18 03.0	+ 58 23	9.3—10.5	5 04.1	1 17; 12 1; 22 9
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	5 16; 12 22; 20 3; 27 9
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	1 19; 8 17; 22 13; 29 11
RZ Scuti	21.1	− 9 15	7.4— 8.3	15 03.2	15 11 30 14
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	1 9; 8 13; 22 20; 30 0
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	1 0; 8 3; 22 9; 29 12
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	5 13; 13 20; 22 4; 30 11
RR Draconis	40.8	+62 34	9.3—13	2 19.9	9 5; 17 17; 26 5
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	1 7; 14 14; 21 5; 27 20
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	17 8; 24 6
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	5 18; 13 9; 21 0; 28 16
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	4 13; 11 17; 19 7; 26 20
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	2 20; 10 1; 24 10; 31 15
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	9 12; 18 11; 27 9
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	7 4; 13 22; 20 17; 27 11
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	2 13; 9 22; 17 7; 24 15
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	4 9; 14 21; 25 9; 30 14
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	1 3; 7 16; 20 17; 27 5
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	4 21; 10 21; 22 21; 28 22
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	1 18; 8 9; 21 15; 28 7
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	9 8; 18 12; 27 15
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	7 6; 15 16; 24 2
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	4 6; 11 1; 17 20; 31 10
UW Cygni	19.6	+42 55	10.5—10.8	3 10.8	3 8; 10 5; 24 0; 30 22
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0	12 21
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	11 13; 21 4; 30 18
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	3 8; 12 12; 21 17; 30 22
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	2 3; 9 14; 17 2; 24 14
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	3 19; 11 10; 19 0; 26 14
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	9 0; 19 2; 29 5
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	5 15; 13 0; 20 10; 27 19
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	5 19; 15 12; 25 5
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	4 11; 12 7; 20 4; 28 1
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	3 2; 13 5; 23 9
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3	29 11
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	4 12; 14 21; 25 6; 30 11
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	5 21; 14 4; 22 11; 30 18
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	7 19; 15 8; 22 21; 30 9
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	9 1; 17 7; 25 12

Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1917. May							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7								
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	5 18;	13 21;	22 0;	30 4				
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	7 0;	14 18;	22 12;	30 6				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	5 12		20 7					
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	4 18;	12 16;	20 15;	28 13				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	3 22;	11 17;	19 12;	27 7				
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	4 22;	12 5;	19 12;	26 19				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0		12	28					
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	5 19;	14 9;	22 23					
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	9 15;	20 18;	31 21					
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	1 0;	12 15;	24 6					
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	4 4;	11 19;	19 11;	27 3				
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	1 23;	12 2;	22 5					
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	6 19;	14 12;	22 5;	29 22				
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	5 12;	11 0;	22 2;	27 15				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	5 5;	12 19;	20 8;	27 22				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3	7 22							
RT Aurigae	23.0	+30 33	5.1— 6.0	3 17.5	7 8;	14 19;	22 6;	29 17				
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	6 15;	13 20;	21 1;	28 6				
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	7 12;	15 10;	23 8;	31 6				
ξ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	3 21;	14 1;	24 5					
RU Camelop.	7 10.9	+69 51	8.5— 9.8	12 06.5		12 19						
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	3 8;	11 17;	19 6;	27 5				
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	4 15;	11 8;	18 1;	31 10				
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	1 15;	10 22;	20 5;	29 11				
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	1 17;	10 11;	19 5;	27 23				
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 0.0		16						
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	3 12;	10 7;	17 2;	30 16				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	5 18;	12 9;	18 23;	25 14				
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	5 12;	15 4;	24 20					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	7 11;	15 11;	23 10;	31 9				
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	7 14;	14 7;	21 1;	27 19				
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	4 4;	10 0;	21 16;	27 11				
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	4 14;	9 6;	18 16;	28 1				
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5		12 2;		29 8				
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	6 19;	15 0;	23 5;	31 10				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	1 19;	8 20;	22 21;	29 21				
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	4 17;	12 22;	21 3;	29 8				
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	5 13;	11 1;	22 0;	27 12				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	3 4;	10 17;	18 6;	25 19				
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	8 8;	15 18;	23 4;	30 14				
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	3 21;	10 16;	24 5;	31 0				
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	3 20;	10 4;	22 19;	29 3				
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	9 20;	19 14;	29 8					
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	9 7;	18 4;	27 0					
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	5 23;	12 0;	24 4;	30 5				
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	2 15;	9 15;	23 16;	30 16				
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9		14 14;		31 16				
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	8 12;	16 2;	23 16;	31 6				
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	3 10;	9 4;	20 17;	26 12				
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	7 1;	13 19;	20 13;	27 7				
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	7 6;	17 14;	27 23					
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	3 5;	9 6;	21 7;	27 8				
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	3 5;	9 9;	21 15;	27 18				
RT Scuti	44.1	−10 30	9.1— 9.7	0 11.9	2 5;	14 3;	26 0;	31 23				
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	8 2;	17 5;	26 7					

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1916. May							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	3 9;	10 9;	24 10;	31 11				
XZ Cygni	19 30.4	+56 10	8.6— 9.3	0 11.2	2 3;	9 3;	23 3;	30 3				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	1 9;	9 9;	17 8;	25 8				
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	6 16;	14 9;	22 1;	29 18				
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	1 13;	8 17;	23 2;	30 6				
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	5 12;	13 21;	22 6;	30 16				
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	1 6;	7 14;	20 5;	26 13				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3		16 13;						
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	1 9;	10 6;	19 3;	28 0				
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	1 11;	8 5;	21 16;	28 10				
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	6 15;	13 8;	20 1;	26 18				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	8 16;		23 9					
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	4 17;	12 14;	20 11;	28 7				
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	4 16;	11 13;	18 11;	25 8				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	3 8;	13 2;	22 18;	27 15				
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	3 22;	12 13;	21 5;	29 20				
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	1 15;	12 9;	23 2;	28 11				
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	9 16;	20 13;	31 10					
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	5 14;	10 23;	24 20;	31 6				
V Lacertae	22 44.5	+55 48	8.5— 9.5	4 23.6	2 3;	12 2;	22 1;	27 0				
X Lacertae	45.0	+55 54	8.2— 8.6	5 10.7	2 5;	7 16;	18 13;	29 10				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	1 16;	12 12;	23 10;	28 20				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	7 6;	13 13;	19 20;	26 3				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4		12 18;	24 21					
V Cephei	23 51.7	+82 38	6.0—7.0	0 23.6	1 13;	11 12;	21 12;	31 11				

COMET AND ASTEROID NOTES.

Search Ephemeris for Comet 1909 IV (Daniel).—Mr. F. E. Seagrave sends us the following ephemeris of Daniel's comet 1909 IV. The comet should have come to perihelion on May 21, 1916, but was then in extremely unfavorable position for observation, being almost behind the sun. It is now out in excellent position so far as the sun is concerned, but its distance from the earth is so great (about 2.34 astronomical units) that it is not likely to be bright enough to be found.

The elements used in computing the ephemeris were:

T = 1916 May 21.758 Greenwich mean time
ω = 3° 31′ 42.80″
Ω = 71 04 18.90 } 1916.0
i = 19 26 41.70
$\log e$ = 9.777790
$\log a$ = 0.540941
μ = 547.763″

EPHEMERIS OF COMET 1909 IV (DANIEL).

Greenwich Midnight 1917	α h m s	δ ° ′ ″	log r	log Δ
April 1	13 43 12	+14 16 09	0.50218	0.35007
5	13 39 16	+14 28 41	0.50544	0.35360
9	13 35 20	+14 38 26	0.50864	0.35787
13 ☍	13 31 25	+14 45 10	0.51180	0.36300
17	13 27 36	+14 48 46	0.51494	0.36890
21	13 23 55	+14 49 9	0.51800	0.37550
25	13 20 24	+14 46 32	0.52106	0.38280
29	13 17 06	+14 40 58	0.52404	0.39068

Comet *b* 1916 (Wolf).—The accompanying diagram shows the apparent course of Wolf's comet *b* 1916 through the constellations Aquila, Delphinus and Pegasus during the months April and May 1917. The comet is disappointing in respect to brightness. Although according to calculation it should be 20 times as bright as when discovered, the writer on the morning of March 20 found it to be barely visible in the five-inch finder of the telescope at Goodsell Observatory. At this rate it will not become anywhere near visible to the naked eye at its best, in August. On April 12 the comet will be a little over a degree due south of the first magnitude star Altair (α *Aquilæ*). Its course passes almost midway between Altair and β *Aquilæ*. During the first of May it will be in the constellation Delphinus, the Dolphin, or Job's Coffin as it is often called.

DIAGRAM SHOWING THE APPARENT PATH OF WOLF'S COMET *b* 1916 THROUGH THE CONSTELLATIONS DURING APRIL AND MAY.

The following ephemeris is continued from page 218 of the March number of POPULAR ASTRONOMY, taken from the Lick Observatory Bulletin No. 289. It was computed by Professor R. T. Crawford of the Berkeley Astronomical Department.

Mr. Seagrave calls attention to a misstatement in the March number of POPULAR ASTRONOMY. The comet will be nearest the earth in August instead of July, the closest approach being on August 21, at 0.986, or about 91,700,000 miles.

Ephemeris of Comet *b* 1916 (Wolf).

(Continued from March POPULAR ASTRONOMY, p. 218.)

1917, Gr. M. T.		True α			True δ		log Δ	Br.
		h	m	s	°	′		
April	25.5	20	19	00	+10	55.2		
	26.5		21	28	11	12.2	0.1994	2.81
	27.5		23	55		29.0		
	28.5		26	22	11	45.9	0.1943	
	29.5		28	49	12	02.8		
April	30.5	20	31	16	+12	19.6	0.1892	3.01

1917, Gr. M. T.		True α			True δ		log Δ	Br.
		h	m	s	°	′		
May	1.5	20	33	43	+12	36.4		
	2.5		36	09	12	53.2	0.1841	
	3.5		38	36	13	09.9		
	4.5		41	02		26.6	0.1791	3.21
	5.5		43	28		43.2		
	6.5		45	55	13	59.8	0.1742	
	7.5		48	21	14	16.4		
	8.5		50	47		32.9	0.1694	3.42
	9.5		53	13	14	49.3		
	10.5		55	38	15	05.7	0.1646	
	11.5	20	58	04		21.9		
	12.5	21	00	29		38.1	0.1599	3.63
	13.5		02	54	15	54.2		
	14.5		05	19	16	10.1	0.1553	
	15.5		07	43		25.9		
	16.5		10	07		41.6	0.1507	3.85
	17.5		12	31	16	57.2		
	18.5		14	54	17	12.6	0.1462	
	19.5		17	17		27.9		
	20.5		19	39		43.1	0.1418	4.06
	21.5		22	01	17	58.1		
	22.5		24	23	18	12.9	0.1374	
	23.5		26	44		27.5		
	24.5		29	05		41.9	0.1330	4.28
	25.5		31	26	18	56.1		
	26.5		33	46	19	10.2	0.1287	
	27.5		36	05		24.1		
	28.5		38	24	19	37.7	0.1245	4.49
	29.5		40	42	19	51.1		
	30.5		43	00	20	04.3	0.1203	
May	31.5		45	17		17.3		
June	1.5	21	47	34	+20	30.0	0.1162	4.71

Brightness 1917 May 5.5 = 1.00. In the ephemeris of *Bulletin No.* **286** the unit of brightness is that of 1916 May 10. With this as the unit, the brightness for 1917 June 1.5 is 79.9.

Ephemeris of Comet *b* 1916 (Wolf).

Gr. M. T. 1917	RA			Dec			Log α	Log Δ
	h	m	s	°	′	″		
June 2	21	49	39	+20	42	33	0.22946	0.11396
6	21	58	37	+21	29	59	0.22820	0.10591
10	22	7	21	+22	13	5	0.22734	0.09798
14	22	15	53	+22	51	15	0.22691	0.09023
18	22	24	9	+23	24	35	0.22693	0.08248
22	22	32	7	+23	52	0	0.22736	0.07498
26	22	39	45	+24	13	37	0.22823	0.06754
30	22	46	41	+24	30	3	0.22947	0.05988

The above ephemeris of Wolf's Comet is based upon elements computed by myself several months ago. I did not compute any positions for April or May because the March POPULAR ASTRONOMY has an ephemeris by the Lick Observatory people for those months and up to June 1, 1917.

Boston, Mass., March 13, 1917. F. E. SEAGRAVE.

Comet *b* 1916 (Wolf).—Mr. Paul Biefeld, director of the Swasey Observatory, Denison University, Granville, O., sends the accompanying diagram, showing the apparent path of Wolf's Comet through the sky from Feb. 26 to Dec. 16, 1917.

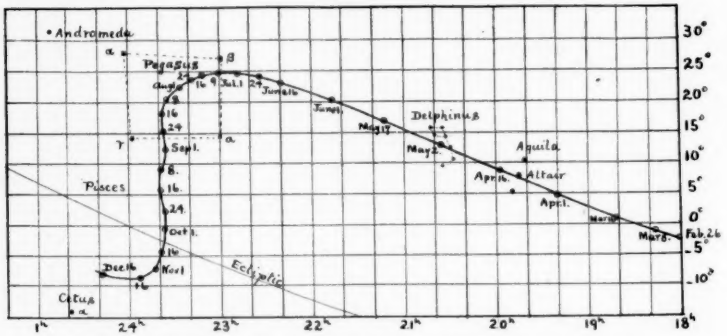


DIAGRAM SHOWING THE APPARENT PATH OF WOLF'S COMET THROUGH THE SKY FROM FEBRUARY 26 TO DECEMBER 16, 1917.

The ephemeris from which the diagram was made follows:

Gr. M. T. 1917		True α h m s	True δ ° ′ ″	Δ
Feb.	26.5	18 00 40	— 2 19 00	2.351
Mar.	5.5	16 40	— 1 12 10	2.240
	16.5	42 10	+ 0 51 30	2.074
Apr.	1.5	19 20 00	4 58 10	1.870
	16.5	56 30	8 25 00	1.683
May	2.5	20 36 05	12 43 30	1.535
	17.5	21 12 20	16 57 10	1.407
June	1.5	48 00	20 28 20	1.308
	16.5	22 20 05	23 08 30	1.220
	24.5	34 30	24 12 20	1.171
July	1.5	48 10	34 10	1.142
	9.5	23 00 50	39 00	1.109
	16.5	12 15	24 21 00	1.077
	24.5	18 50	23 32 40	1.047
Aug.	1.5	25 50	22 22 50	1.011
	8.5	34 30	20 33 20	1.007
	16.5	38 40	18 03 30	0.992
	24.5	37 20	15 18 40	0.983
Sept.	1.5	36 20	12 06 20	0.993
	8.5	39 10	9 00 40	1.022
	16.5	39 30	5 34 30	1.067
	24.5	35 20	+ 2 26 00	1.120
Oct.	1.5	35 50	— 0 09 30	1.194
	16.5	39 50	4 27 40	1.382
Nov.	1.5	43 10	7 10 20	1.632
	16.5	53 50	8 29 10	1.918
Dec.	16.5	24 18 30	— 8 14 20	2.559

New Comet *a* 1917 (Mellish).—A telegram from Harvard College Observatory received March 20, announced the discovery of a new comet by Mr. John E. Mellish, of Leetonia, Ohio, on March 19. Its position was given only roughly as

March 19 R.A. $2^h\ 07^m$, Dec. $+14°$.

The comet was looked up with the telescope at Goodsell Observatory on March 20. Although in rather thick haze, at a low altitude, it was easily seen with the 5 inch finder and a fair set of measures were taken for its position with the 16 inch telescope. Unfortunately the comparison star could not be identified with certainty at that time. Later observations will probably enable us to make the identification certain.

The comet is nearly round, very much condensed, with an almost stellar nucleus. It is easily seen on a clear night with a small telescope. On March 23 Dr. Gingrich thought he could see a short tail with the 16 inch.

The comet is in the constellation Aries, moving slowly northwestward. During the first days in April it will be in the vicinity of β Arietis.

The following are all the observations of position which have come to hand:

G. M. T. 1917	α h m s	δ ° ′ ″	Observer	Place
March 20.5932	2 09 40.13	+14 25 28.8	Wilson	Northfield
21.5681	. . .	+14 45 43.8	Wilson	Northfield
21.5731	2 09 14.95	. . .	Wilson	Northfield
21.6479	2 09 12.2	+14 47 14	Shane	Mt. Hamilton
22.3093	2 08 51.1	+15 01 04	Strömgren	Copenhagen
23.5769	2 08 05.60	+15 28 11.4	Wilson	Northfield
24.5338	2 07 23,4	+15 48 02	Burton	Washington

NOTES FOR OBSERVERS.

Monthly Report of the American Association of Variable Star Observers, February, 1917.

Both the number of observations and number of variable stars observed show a good increase in this report over the month of February 1916. Mr. H. C. Bancroft, Jr.'s list of 241 observations of 176 variables contributes largely to this good showing for a Winter month. The number of observers shows a decrease from the corresponding month of last year owing to interruption in the mail service which has deprived us of the lists of observations made by members residing in Holland, Italy and Switzerland.

During February the irregular variables 060547 SS Aurigae and 213843 SS Cygni had long maxima which were well observed.

We welcome to membership in our Association, Mr. Charles H. Cramer (Ca), of Sandusky, Ohio, and Mr. C. E. Barns (Bns), of Morgan Hill, Santa Clara County, California. Mr. Barns observes with a 4″ refractor. Reports of observations have been received from Mr. R. W. French (F), now in charge of the Observatory of the College of Hawaii, Honolulu, H. I., and Mr. Edward Bryan (By), also connected with that Observatory.

The Reverend Tilton C. H. Bouton, and Messrs. F. E. Brasch, H. O. Eaton, C. Y. McAteer and F. E. Spinney, members of our Association, had the honor of being elected to membership in the American Astronomical Association at their January Meeting in New York City.

Letters received from our Secretary, Mr. William Tyler Olcott, tell of a delightful trip through Cuba and Jamaica, which has been extended to the Panama Canal and Costa Rica.

074922 U Geminorum has been at minimum, magnitude 14.0, throughout the entire month, the star needs careful watching as it may rise at any time. SS Aurigae

VARIABLE STAR OBSERVATIONS February, 1917.

Feb. 0 = J. D. 2421260; Mar. 0 = 2421288; Apr. 0 = 2421319.

001046
X Androm.

J.D.	Est.	Obs.
242		
1266.5	9.8	Ba
69.5	10.0	V
74.6	9.1	B
77.5	8.8	Ba
82.5	9.0	V

001726
T Androm.

1281.5	11.2	Ba

001755
T Cassiop.

1270.6	9.9	Ba
78.5	9.8	D
79.6	9.3	Mc
81.6	9.7	Ba
81.6	9.9	S

001838
R Androm.

1260.5 <	10.6 Wh
82.5 <	11.0 Wh

003179
Y Cephei

1270.6	12.7	Ba
78.6	10.5	Hu
84.6 <	11.8	Wh

004047
U Cassiop.

1260.6 <	11.1	Wh
77.6 <	12.5	Y
78.6 <	12.5	Ba
82.6	10.5	Wh

004435
V Androm.

1277.5 <	12.5	Ba
78.6 <	13.0	Hu

004533
RR Androm.

1277.5 <	12.5	Ba

004746
RV Cassiop.

1278.6 <	12.5	Ba

004958
W Cassiop.

1270.6	11.8	Ba
77.6	11.8	Y
78.6	11.7	Ba

010940
U Androm.

J.D.	Est.	Obs.
242		
1281.5 <	12.0	Ba

011208
S Piscium

1276.6	11.0	B
81.5	11.1	Ba

011272
S Cassiop.

1270.6	9.1	Ba
70.6	9.3	B
76.6	9.3	B
78.6	9.5	D
84.6	9.6	Wh
84.7	9.1	Ba

011712
U Piscium

1281.5 <	12.3	Ba

012350
RZ Persei

1270.6	12.0	Ba
77.6	11.8	Y
78.6	11.1	Ba

012502
R Piscium

1281.5 ±	12.0	Ba

013238
RU Androm.

1277.5	10.2	Ba

013338
Y Androm.

1277.5	11.3	Ba

014958
X Cassiop.

1277.6	11.6	Y
78.6	12.0	Ba
84.7	11.8	Ba

015354
U Persei

1256.6	8.7	B
66.6	8.7	Ba
69.5	8.9	V
70.6	9.1	B
74.6	9.4	B
77.7	9.8	Mu
78.6	9.0	Hu
78.6	9.4	Ba

U Persei

J.D.	Est.	Obs.
242		
1282.6	9.2	V
82.6	10.1	Wh
82.5	9.7	D
84.7	9.8	Ba
84.6	9.6	B

015912
S Arietis

1274.6	12.1	B
81.6	11.6	Ba
84.6	12.2	B

021024
R Arietis

1281.6	9.6	Ba
84.5	9.6	S

021143
W Androm.

1266.6	10.8	Ba
78.6	10.1	Ba

021281
Z Cephei

1269.6 <	11.5	V

021403
o Ceti

1273.6	5.4	Mu
74.7	5.5	Mu
77.5	5.8	Ba
78.6	5.2	Hu
82.5	5.4	D

021558
S Persei

1266.6	8.8	Ba
74.6	8.9	B
77.5	8.8	Ba
78.6	8.5	Hu
84.6	9.1	B
84.7	8.7	Ba

022000
R Ceti

1281.6 <	11.5	Ba

022150
RR Persei

1277.5 <	13.0	Ba
81.6	13.5	Y

022813
U Ceti

1281.6	8.4	Ba

023080
RR Cephei

J.D.	Est.	Obs.
242		
1269.6	10.7	V

023133
R Triang.

1270.6	9.3	Ba
70.6	9.6	B
76.6	9.7	B
78.6	9.6	Ba
78.6	9.6	Hu
78.6	9.6	Wh

024356
W Persei

1266.6	8.9	Ba
77.6	8.9	Ba
77.7	9.3	Mu
78.6	9.1	Hu
82.6	9.5	D
84.7	8.9	Ba

030514
U Arietis

1270.6	11.7	Ba
78.6	10.1	Ba
81.6	9.9	Y
82.6	9.7	D

031401
X Ceti

1281.6 <	12.5	Ba

032043
Y Persei

1259.6	8.5	B
66.6	8.3	Ba
77.7	9.6	Mu
78.6	8.2	Ba
78.6	8.5	Hu
80.6	8.9	B
84.7	9.0	Ba

032335
R Persei

1278.6	12.5	Hu
78.6	12.0	Ba
81.6	12.9	Y

033362
U Camelop.

1266.6	7.7	Ba
78.6	7.6	Ba
82.6	8.2	Wh

035915
V Eridani

1277.6	9.1	Ba

041619
T Tauri

J.D.	Est.	Obs.
242		
1279.5	10.2	Mc

042209
R Tauri

1278.6 <	13.0	Ba

042215
W Tauri

1266.6	11.0	Ba
70.6	11.5	Ba
74.6	11.4	B
76.7	10.9	Wh
77.7	10.9	Mu
77.6	11.5	Ba
78.6	11.4	Hu
78.6	11.6	Pi
79.5	11.0	Mc
84.6	12.0	Ba
84.6	12.1	B

042309
S Tauri

1278.6 <	13.0	Ba

043065
T Camelop.

1277.6	8.8	Ba
81.6	9.2	Y
84.7	8.8	Ba

043208
RX Tauri

1277.6	13.0	Ba
78.6	12.8	Hu
80.6 <	12.1	B
81.6	13.0	Y

043274
X Camelop.

1269.6	9.8	V
77.6	11.3	Cr
78.6	11.5	Ba
82.6	11.3	V
82.6	11.4	Cr
84.6	11.6	Cr
84.7	11.5	Ba

044617
V Tauri

1277.6	13.0	Ba
78.6 <	12.3	Pi
79.6 <	12.7	B
81.6 <	13.0	Y

VARIABLE STAR OBSERVATIONS February, 1917—Continued.

045307
R Orionis

J.D. 242	Est.	Obs
1277.6	11.2	Ba
79.6	11.6	B

045514
R Leporis

1270.6	7.5	B
74.7	8.1	Me
77.5	8.9	Mc
77.6	7.7	B
78.6	7.3	Ba

050003
V Orionis

1276.6	<12.3	Wh
77.6	<13.0	Ba
81.6	<13.0	Y

050022
T Leporis

1277.5	9.2	Mc
77.6	9.4	Ba

050953
R Aurigae

1277.6	12.9	Ba
79.6	<12.4	B
80.7	<11.5	Mc

052034
S Aurigae

1277.6	10.0	B
78.6	9.1	Ba
78.7	10.1	Wh
80.6	9.9	Mc
84.7	9.7	Ba

052036
W Aurigae

1270.6	9.7	Ba
77.6	9.9	B
78.6	9.6	Ba
80.6	9.6	Mc
84.7	9.7	Ba

052404
S Orionis

1270.5	8.7	B
75.5	8.2	Mc
77.6	8.7	Ba
78.6	9.0	Pi
84.6	9.0	B

053005a
T Orionis

J.D. 242	Est.	Obs.
1266.6	<10.3	Bu
68.7	10.9	By
70.5	11.2	B
70.8	11.1	By
71.8	10.6	By
75.5	<10.4	Mc
74.6	10.5	Wh
77.6	10.5	Ba
78.6	10.4	Pi
78.7	10.2	Me
79.5	11.0	Mc
84.7	10.0	Ba
84.5	10.0	B

053068
S Camelop.

1278.6	9.9	Ba
81.6	9.6	Y
84.7	9.5	Ba

053531
U Aurigae

1277.6	<13.0	Ba
80.7	11.3	Mc
82.6	11.1	B

054319
SU Tauri

1259.6	9.7	B
66.6	9.8	Ba
69.6	9.9	V
70.6	9.7	Ba
72.6	9.6	V
74.5	9.4	V
76.7	9.8	Wh
77.5	9.5	V
77.6	9.8	B
77.5	9.7	Ba
78.6	9.6	Ba
78.6	9.9	Cr
78.6	9.9	Pi
80.6	9.9	B
81.6	9.7	Ba
81.6	9.7	Y
82.6	10.0	B
82.6	9.6	Wh
82.6	9.5	V
84.6	9.9	Ba
84.6	9.9	B

054615a
Z Tauri

1281.6	<13.0	Y

054615c
RU Tauri

1281.6	<13.0	Y

054920
U Orionis

J.D. 242	Est.	Obs.
1266.6	<11.6	Bu
77.6	11.6	Ba
78.6	11.4	Cr
78.6	11.9	Pi
78.6	11.2	Hu
81.6	11.6	Y
84.7	11.3	Ba

054974
V Camelop.

1270.6	<13.3	Ba
77.5	<13.3	Ba
78.6	<13.0	Ba
81.6	13.0	Y
81.6	<13.0	Ba
84.6	<12.8	Cr
84.6	<13.0	Ba

055353
Z Aurigae

1277.6	9.7	Ba
80.6	9.3	Mc
84.7	9.5	Ba

060450
X Aurigae

1277.6	12.0	B
77.5	11.8	Ba
82.7	11.6	Wh
84.7	11.5	Ba
84.5	11.4	Y

060547
SS Aurigae

1260.6	<12.6	Hu
70.6	10.6	Ba
70.6	10.7	V
72.6	10.7	V
74.6	10.9	V
75.5	11.2	Mc
77.5	10.8	Ba
77.5	11.3	Mc
77.6	11.3	B
77.6	10.9	V
78.6	11.3	Ba
78.6	11.6	Pi
79.7	<12.0	Mc
80.7	<12.4	Wh
80.7	<12.0	Mc
81.6	<12.4	Cr
81.6	13.3	Ba
82.6	<12.4	Cr
82.6	<13.3	Y
82.6	<11.4	V
84.6	<12.4	Cr
84.7	<13.0	Ba
84.5	<13.3	Y

061647
V Aurigae

J.D. 242	Est.	Obs.
1277.6	11.1	Ba
80.7	11.4	Mc

061702
V Monoc.

1266.6	9.0	Bu
77.6	10.3	Ba
78.5	10.6	Pi
79.6	9.8	Mc

063159
U Lyncis

1266.6	<11.8	Bu
77.6	13.9	Ba
82.6	13.6	Y

063308
R Monoc.

1278.5	<12.3	Pi

063558
S Lyncis

1266.6	<11.9	Bu
77.6	13.0	Ba
82.6	<12.6	Y

064030
X Gemin.

1266.7	11.3	Bu
70.6	10.7	V
77.6	10.3	Ba
77.6	10.5	Mc
82.6	10.2	V
84.7	9.7	Ba

065111
Y Monoc.

1262.6	9.3	Bu
78.5	9.4	Pi
79.6	9.2	Ba
83.6	8.9	V

065208
X Monoc.

1260.6	7.8	Hu
66.6	7.4	Bu
78.5	7.6	Pi
78.6	7.3	Ba
79.5	8.0	Mc

065355
R Lyncis

1277.7	10.0	B
77.6	9.8	Ba
84.5	9.5	Y

070122a
R Gemin.

J.D. 242	Est.	Obs.
1260.6	10.0	Hu
65.6	9.7	B
71.6	10.4	Bu
77.5	10.0	Y
77.6	9.9	Mc
78.6	10.5	Ba
80.6	11.2	B

070122b
Z Gemin.

1271.6	<12.1	Bu
77.6	<10.8	Mc
78.6	12.4	Ba

070122c
TW Gemin.

1271.6	8.6	Bu
77.6	8.4	Mc
78.6	8.5	Ba

070310
R Can. Min.

1260.6	10.4	B
66.6	10.9	Bu
77.6	9.6	Mc
78.6	9.3	Ba

071713
V Gemin.

1266.6	10.7	Bu
70.6	9.6	V
77.6	9.4	Mc
78.6	8.8	Ba
84.6	8.0	V

072708
S Can. Min.

1260.6	9.2	B
66.6	9.3	Bu
74.6	9.9	Wh
77.5	9.6	Mc
77.7	10.2	Mu
77.7	9.8	Ba
80.6	10.2	B
81.7	10.3	D
84.6	10.2	S

072811
T Can. Min.

1260.6	<12.5	B
78.6	<12.5	Ba
80.6	<12.3	B

VARIABLE STAR OBSERVATIONS February, 1917—Continued.

073508
U Can. Min

J.D. 242	Est.	Obs.
1260.6	9.2	B
66.6	9.5	Bu
70.8	9.3	By
77.5	9.4	Mc
77.7	9.2	Ba
77.5	9.3	Y

073723
S Gemin

1266.6<11.9		Bu
72.5	12.0	Cr
77.5	10.8	Y
77.5	11.1	Cr
78.6	10.5	Ba
78.6	10.5	Cr
81.6	10.3	Cr
82.5	10.2	B
82.7	10.4	Wh
84.7	9.9	Ba
84.6	9.8	V

074323
T Gemin.

1270.6<11.9		Bu
77.5	12.9	Y
77.6<11.2		Mc
78.6	13.0	Ba
84.7	12.6	Ba

074922
U Gemin.

1260.6<12.4		B
62.6<12.3		Bu
66.6<11.7		Bu
70.6<13.0		Ba
70.6<11.7		V
71.6<12.3		Bu
72.6<11.7		V
74.6<11.7		V
76.7<12.3		Wh
76.6<12.5		B
77.5<12.4		Y
77.6<12.7		B
77.5<12.4		Cr
77.5<13.5		Ba
77.6<11.7		V
77.6<10.9		Mc
78.5<12.4		Cr
78.6<13.3		Ba
79.6<12.5		B
79.6<12.4		Mc
80.6<11.7		Cr
80.6<12.5		B
81.6<13.3		Ba
81.6<11.7		Cr
81.6<13.3		Y
82.6<12.5		B

U Gemin.

J.D. 242	Est.	Obs.
1282.7<12.4		Wh
82.6<11.7		V
84.6<13.3		Ba
84.6<12.5		B

075612
U Puppis

1277.5<12.2		Y
78.6<12.8		Ba

081112
R Cancri

1260.6	8.6	Hu
66.6	8.8	B
70.6	8.9	Bu
77.7	8.8	Ba
78.5	9.1	Pi
80.6	8.7	B
86.6	8.6	Mc

081617
V Cancri

1260.6	10.1	B
70.6	10.0	Bu
78.5	11.1	Pi
78.7	11.0	Ba
80.6	11.5	B
86.6	10.2	Mc

081633
T Lyncis

1280.7	9.0	Mc

082405
RT Hydrae

1276.6	7.5	B
78.7	7.1	Ba

083019
U Cancri

1270.6<11.1		V
70.6<11.9		Bu
78.7<12.8		Ba
84.5±13.0		Y

083350
X Urs. Maj.

1281.6	9.4	Ba

084803
S Hydrae

1278.7	10.9	Ba
80.7	11.4	Mc
82.6	10.6	B
84.7	10.7	Ba

085008
T Hydrae

J.D. 242	Est.	Obs.
1278.7	12.0	Ba

085120
T Cancri

1270.6	9.7	Bu
76.6	8.4	B
78.6	9.0	Pi
81.6	8.1	Ba
81.6	8.4	Hu

090151
V Urs. Maj.

1270.6	10.3	B
70.6	9.9	V
77.6	10.2	B
77.7	9.8	Mu
81.6	10.2	Ba
81.6	9.5	Hu
84.6	10.2	V

090425
W Cancri

1281.6±12.9		Ba
84.5<13.2		Y

093014
X Hydrae

1281.6	10.1	Ba

093178
Y Draconis

1282.6<13.4		Y

093934
R Leo. Min.

1279.6	8.3	Mc
81.6	8.3	S
81.6	7.5	Ba
81.6	7.7	Hu
81.6	7.9	Bu

094211
R Leonis

1270.6	8.8	B
70.6	9.6	Bu
74.7	9.9	Me
76.6	8.9	B
77.6	10.0	Cr
77.7	9.7	Mu
78.7	8.8	Ba
78.6	9.8	Wh
79.6	9.8	Mc
81.6	9.5	Cr
81.7	10.1	S
81.7	9.4	D

094622
Y Hydrae

J.D. 242	Est.	Obs.
1281.6	6.4	Ba

095421
V Leonis

1281.6	12.5	Ba
84.5<12.8		Y

103212
U Hydrae

1281.6	5.2	Ba

103769
R Urs. Maj.

1270.6	11.4	B
70.6	11.5	Ba
77.6	11.8	Ba
79.7	11.9	Mc
81.6	11.9	Cr
84.7	12.1	Ba

104620
V Hydrae

1281.6	6.8	Ba
81.7	7.8	D

104814
W Leonis

1270.6<12.0		B
79.6	12.6	B
81.6	12.5	Ba

115919
R Comae Ber.

1277.7<12.5		Ba

120012
SU Virginis

77.7<12.3		Ba

120905
T Virginis

1277.7	10.2	Ba

121418
R Corvi

1277.7	7.5	Ba

122001
SS Virginis

1277.7	7.1	Ba

122532
T Can. Ven.

1270.6	9.7	Ba
77.7	9.5	Ba
80.7	9.6	Mc
84.6	9.4	Wh

122803
Y Virginis

J.D. 242	Est.	Obs.
1277.7	11.7	Ba

123160
T Urs. Maj.

1266.6	6.7	Ba
70.6	7	Ba
76.7	7.5	Wh
77.6	7.2	Ba
79.6	7.9	Mc
81.6	7.0	Hu
81.6	7.7	S
81.6	7.0	Bu
84.8	7.5	Ba
86.6	8.0	Mc

123307
R Virginis

1277.7	9.1	Ba
84.8	8.8	Ba

123459
RS Urs. Maj.

1276.7<11.0		Wh
77.6<12.0		Ba
79.6<10.6		Mc
84.8<13.5		Ba

123961
S Urs. Maj.

1266.6	9.1	Ba
70.6	8.8	Ba
74.6	8.7	B
76.7	8.9	Wh
77.6	8.4	Ba
79.6	8.9	Mc
81.6	8.5	Hu
81.6	8.8	S
81.6	8.6	Bu
84.8	8.2	Ba
84.6	8.6	B
86.6	8.7	Mc

124204
RU Virginis

1277.7	11.8	Ba

124606
U Virginis

1277.7	11.9	Ba
84.8	12.4	Ba

132202
V Virginis

1284.8	11.0	Ba

VARIABLE STAR OBSERVATIONS February, 1917—Continued.

132422
R Hydrae
J.D. Est.Obs.
242
1284.8 7.5 Ba

132706
S Virginis
1277.7 7.7 Ba

133273
T Urs. Min.
1284.8<13.0 Ba

134440
R Can. Ven.
1270.6 8.9 Ba
80.7 9.2 Mc
81.7 11.1 S
84.8 9.3 Ba

135908
RR Virginis
1284.8<13.1 Ba

140113
Z Bootis
1284.8<13.4 Ba

140512
Z Virginis
1284.8<12.8 Ba

141567
U Urs. Min.
1270.5 10.0 Ba
78.7 10.6 Wh
81.6 10.8 S
81.6 10.6 Bu
84.8 10.6 Ba

141954
S Bootis
1277.6 11.0 Ba

142205
RS Virginis
1284.8 13.5 Ba

142539
V Bootis
1277.7 8.1 Ba
81.7 8.1 S

142584
R Camelop.
1259.6 8.6 B
66.6 8.4 Ba
78.6 8.3 Wh
80.6 8.1 B

143227
R Bootis
J.D. Est.Obs.
242
1277.7 7.7 Ba
81.9 8.3 Mc

144918
U Bootis
1277.7 11.1 Ba

150018
RT Librae
1284.8±13.0 Ba

150519
T Librae
1284.8<12.0 Ba

150605
Y Librae
1284.8 13.2 Ba

151520
S Librae
1284.8 8.8 Ba

151731
S Cor. Bor.
1277.7 7.4 Ba

151822
RS Librae
1284.8 10.2 Ba

152714
RU Librae
1284.8 8.1 Ba

153378
S Urs. Min.
1259.6 8.7 B
70.5 8.6 Ba
78.6 8.2 Wh
80.6 8.3 B
86.7 8.8 Mc

154428
R Cor. Bor.
1277.7 6.0 Ba
78.7 6.0 Wh
81.9 6.0 Mc
84.7 5.8 Ba

154536
X Cor. Bor.
1277.7 9.0 Ba

154539
V Cor. Bor.
J.D. Est.Obs.
242
1277.7 7.5 Ba

154615
R Serpentis
1284.8 7.0 Ba

155229
Z Cor. Bor.
1277.7<12.0 Ba

160118
R Herculis
1284.8 9.1 Ba

160210
U Serpentis
1284.8<12.3 Ba

160625
RU Herculis
1284.8 13.4 Ba

161138
W Cor. Bor.
1277.7 11.3 Ba

161607
W Ophiuchi
1284.8<12.7 Ba

162112
V Ophiuchi
1284.8 8.2 Ba

162119
U Herculis
1281.9 11.6 Mc
84.8<12.5 Ba

162807
SS Herculis
1284.8 9.9 Ba

162816
S Ophiuchi
1284.8<12.0 Ba

163137
W Herculis
1277.7 9.0 Ba
81.9 9.3 Mc

163172
R Urs. Min.
1270.5 9.0 Ba
78.6 9.3 Wh

163266
R Draconis
J.D. Est.Obs.
242
1270.6 10.8 Ba
78.7 11.0 Wh
79.7 10.2 Mc
81.6 <9.8 S

164055
S Draconis
1281.9 8.7 Mc

164319
RR Ophiuchi
1284.8 11.0 Ba

164715
S Herculis
1281.9 8.2 Mc
84.8 7.9 Ba

165631
RV Herculis
1284.8<13.4 Ba

170215
R Ophiuchi
1284.8 8.8 Ba

170627
RT Herculis
1284.8 9.0 Ba

171401
Z Ophiuchi
1284.9 8.5 Ba

171723
RS Herculis
1284.9 10.2 Ba

172809
RU Ophiuchi
1284.9<12.6 Ba

175111
RT Ophiuchi
1284.9<12.7 Ba

175458
T Draconis
1281.9<11.4 Mc

180531
T Herculis
1281.9 11.2 Mc

181136
W Lyrae
1281.9 7.8 Mc
84.9 8.0 Ba

183308
X Ophiuchi
J.D. Est.Obs.
242
1284.9 8.7 Ba

184205
R Scuti
1284.9 5.5 Ba

184243
RW Lyrae
1284.9<13.4 Ba

202946
SZ Cygni
1270.5 10.0 Ba

210382
X Cephei
1281.6<13.4 Y

210868
T Cephei
1270.6 6.3 Ba
78.6 6.9 D
84.6 7.2 S

213678
S Cephei
1270.6 11.5 Ba
78.6 10.0 D

213843
SS Cygni
1260.5 8.9 B
61.5 8.3 Pi
62.6 8.7 Bu
62.5 8.7 Wpi
63.5 8.8 B
63.5 8.3 Pi
65.5 8.7 B
65.6 8.5 Bu
66.5 8.6 B
66.5 8.2 Pi
67.5 8.7 B
68.6 8.7 Bu
69.5 8.7 B
70.5 8.9 B
70.5 8.4 Ba
71.6 9.3 Bu
78.5<11.3 Pi

230110
R Pegasi
1259.5 9.5 Wh

VARIABLE STAR OBSERVATIONS February, 1917—Continued.

230759 V Cassiop.			233335 ST Androm.			233956 Z Cassiop.			235350 R Cassiop.			235525 Z Pegasi		
J.D. 242	Est.	Obs.	J.D. 242	Est.	Obs.	J.D. 242	Est.	Obs.	J.D. 242	Est.	Obs.	J.D. 242	Est.	Obs.
1266.6	7.9	Ba	1260.6	10.3	Wh	1270.6	<13.4	Ba	1266.5	±5.8	Ba	1269.5	<10.6	V
70.6	7.9	B	60.5	9.8	B				70.6	7.0	B			
76.6	8.3	B	66.5	10.0	Ba				76.6	6.9	B	235939 SV Androm.		
82.6	9.0	Wh	78.6	9.1	Hu				78.5	6.9	D	1260.6	<11.6	Wh
			84.5	9.5	S							70.6	12.7	Ba
												84.5	12.5	Y

No. of observations 636; No. of stars observed 191; No. of observers 17.

seems to have the long and short type of maxima similar to 074922 U Geminorum and 213843 SS Cygni. The variable 063308 R Monocerotis is of special interest, being involved in the head of a small nebula, and more observations of the star have been requested by Professor Shapley. Mr. D. B. Pickering is having copies of the chart of 063308 R Monocerotis made for distribution. Those with fairly large telescopes who desire to observe it may secure copies by communicating with the Acting Secretary of the American Association of Variable Star Observers. This star is now at about 11th magnitude.

An error occurs on page 203 of the March POPULAR ASTRONOMY for the variable star 000843 SY Androm: for 16.0 read 10.6.

The following predicted dates of Maxima taken from the "Companion to the Observatory" and Harvard College Observatory Circular 197 will be of interest to observers of long period variable stars:

CALCULATED DATES OF MAXIMA.

From the Companion to the Observatory	Dates predicted by Mr. Leon Campbell	
Apr. 7	Apr. 21	171401 Z Ophiuchi
10	17	021143 W Andromedae
14	3	021024 R Arietis
19	3	154615 R Serpentis
24	May 11	043065 T Camelop.
26	11	194048 RT Cygni

The following members contributed to this report: Messrs. Bancroft, Bouton, Burbeck, Bryan, Crane, Ducharme, French, Hunter, McAteer, Meeker, Mundt, D. B. Pickering, S. W. Pickering, Whitehorn, Vrooman, Miss Swartz, and Miss Young.

JOHN J. CRANE,
Acting Secretary.

March 10, 1917.

Betelgeuse (α Orionis).—Mr. F. E. Seagrave calls the attention of variable star observers to α Orionis. He says "Just a year ago at this time (March 1916) this star was way down, and just equal to Aldebaran. It remained so for many weeks. During the summer and early autumn months it brightened, for my records show that after the middle of November it was fully 0.15 magnitude brighter than Aldebaran and only 0.25 magnitude fainter than Rigel. From that time (Nov. 26, 1916) there seemed to be a 'standstill' until about the middle of January this year. Since January 13 the star has again declined and is now (March 6-7) just equal to Aldebaran again. This is an interesting variable and I have given it much attention for the past five years. I would like to know if variable star observers agree with me."

COMMUNICATIONS.

The Aurora Borealis in 1916.—Following is a record of my observations of the Aurora Borealis in 1916, given in C. S. T.:

Jan. 22, 7^h 30^m. Plain light, very bright. April 22, 8^h. Streamers could be traced as high as Polaris; later it changed to a long bright arc of light. Aug. 19, 9^h. Plain light, no streamers. Aug. 26, 8^h 30^m. One of the grandest auroral displays ever seen by the writer. Streamers came up as high as Vega and the Northern Cross. Waves of light resembling sheet lightning came rolling up as high as Polaris. Streamers, pointing from nearly west to east, formed south of Arcturus. A little later these streamers formed into a broad band of nebulous white light, which extended east to the Milky Way, south of Altair; the light in this band was brightest south of the head in Serpens. At 8^h 40^m this band of light faded away and a streamer came up nearly due west of Arcturus, pointing slightly southeast, but which soon faded away. After that there was a constant display of streamers, bands and arcs of light forming and fading away. Most of the streamers came up from the north and northwest. It was cloudy in the northeast so I could not see how far east the light extended. At 9^h 30^m, when I retired, it was nearly as light as when the full moon is shining. Sept. 24, 8^h. Plain light, no streamers. Sept. 30, 8^h. One large streamer came up through the handle of the Big Dipper, farther east it was just a plain light. Oct. 6, 7^h. Very bright, changing constantly. Several times arcs of light formed, but instead of being convex, they were concave. A few streamers came up nearly as high as the Northern Cross.

Port Byron, Ill., March 12, 1917. J. J. SCHAFER.

GENERAL NOTES.

Major P. A. MacMahon has been elected president of the Royal Astronomical Society in succession to Dr. R. A. Sampson.

Mr. W. S. Adams, of the Mount Wilson Solar Observatory has been awarded the gold medal of the Royal Astronomical Society (London) for his investigations in stellar spectroscopy.

Dr. Robert G. Aitken, astronomer at the Lick Observatory, has been granted four months' leave of absence by the University of California, to go to the Atlantic coast to complete arrangements for the publication of his work on the double stars. He has been scheduled to speak, on March 23, before the Geographic Society of Chicago on "The Work of Two Mountain Observatories."

The Adams Prize at Cambridge has been awarded to Mr. J. H. Jeans, M. A., sometime fellow of Trinity, for an essay on "Some Problems of Cosmogony and Stellar Dynamics." No election has been made to the Isaac Newton Studentship.

Messrs. Brashear and Swasey entertained at Manila.—On February 5, 1917, Dr. John A. Brashear, the noted American maker of photographic lenses and silver-on-glass mirrors, Dr. A. Swasey, President of the firm that made the mounting of the big Cordoba, Lick, Yerkes, Victoria telescopes, and Dr. John R. Freeman, the leading American hydraulic engineer, were entertained at a lunch given in their honor at the Manila Hotel by prominent scientists and engineers of Manila. To meet in the far off Philippine Islands so many friends, enthusiastic for astronomy and for the application of modern machinery and methods to engineering problems, was a delightful surprise to the distinguished visitors. José Algué, Director of the Weather Bureau, welcomed the guests and acted as toast master. The speaker of the occasion was a personal friend of Dr. J. A. Brashear. Speaking of optical instruments made by Brashear, Rev. M. Selga, well known in America for his connection with the leading American Observatories, made the following remarks: "There is hardly any remarkable astronomical observatory in America that is not equipped either with a silver-on-glass mirror, or a lens, or a comet-seeker, alt-azimuth or spectrograph constructed by Brashear. The 8″ doublet of Swarthmore College Observatory, the 15″ of the Dominion Observatory, Ottawa, Canada, the 18″ of the Flower Observatory, Philadelphia, Pa., the 20″ of Chabot Observatory, Oakland, California, the focus of the astronomical admiration of the visitors at the Panama Pacific Exhibition, the unique 30″ photographic refractor of the Allegheny Observatory, are but few among the many high grade refractors turned out by Brashear. You are all acquainted with the spectrographic investigations of the late Dr. Young, at Princeton, of Dr. G. E. Hale at Kenwood, paving the way for the advance of solar physics and the establishment of the Mt. Wilson Solar Observatory, of Dr. F. Schlesinger at the Allegheny Observatory with the Mellon and Porter spectrographs, of Dr. Frost with the Bruce, of Plaskett at Ottawa, of Dr. Slipher at Flagstaff, and specially of Dr. W. W. Campbell, who with the Mills spectrograph has surveyed the northern and southern skies for the spectral characteristics of the stars. Now, some of the vital parts, either the prisms or the lenses, of these unparalleled spectrographs are from Brashear." The guests gathered around the table at 12 o'clock and the steamer was to take the scientific party from Manila to Hongkong at 3 p. m. Few minutes were left to Dr. Brashear to talk on the stars, to Dr. Swasey to give his views about the Far East and to Dr. Freeman to report on the past, present and future condition of the Panama landslides. The speeches were short, but they were a source of pleasure and delight to more than a hundred guests and will be long remembered.

Sunspot of February 9, 1917.—Professor Edwin B. Frost, director of the Yerkes Observatory has very kindly sent us a copy of a photograph of the great sunspot which was visible to the naked eye during the greater part of the month of February. The spot group was over 125,000 miles long.

The photograph was taken by Miss Mary R. Calvert with the 12-inch telescope of the Yerkes Observatory, with the lens stopped down to 1½ inches. The positive from which the engraving, Plate X, was made was prepared by Prof. E. E. Barnard.

Tables of Rising and Setting of the Sun and Moon.—A supplement to the American Ephemeris for 1917 has been issued containing tables giving the times of rising and setting of the sun and moon for the years 1917 and 1918. Such tables are, beginning with 1919, to be included in the future volumes of the American Ephemeris and Nautical Almanac. Copies of the supplement can be had by applying to the Superintendent of Documents, Government Printing Office, Washington, D. C. Price fifteen cents.

Publications of the Observatory of the National University of La Plata, Volume III.—This volume, recently received, contains the results of observations made with the Gautier Meridian Circle during 1913, 1914, 1915 for determining star positions in the zone from −52° to −61°. The plan of the program, of which the results are given in the volume mentioned, was to observe all the stars to the ninth magnitude given in the *Cape Photographic Durchmusterung*, numbering about 7,500 between −52° and −56°, and about as many more from −57° to −61°. This therefore was a large and important undertaking. It is a valuable addition to the available star catalogues since, because of the scarcity of observatories in the southern hemisphere, the southern stars have not been so well observed as those of the northern hemisphere. This work was planned and carried out by Felix Aguilar and Paul T. Delavan, and their assistants.

Extension of the Weather Bureau Service.—From a communication to Science (March 16, 1917) by Charles F. Brooks of Yale College we obtain the following with reference to extensions of the Weather Bureau Service in the near future:

"Out of the $81,210 increase in the appropriation for the Weather Bureau for the current fiscal year, $50,000 has been designated for extensions of the service. The largest item, $30,000 is to be applied for the increase in weather reports from the West Indies and Central America. It is probable that some 10 new stations will be established, and that closer cooperation between the Weather Bureau and the meteorological service of Cuba and the British colonies will be effected. If these plans are carried out there will be about twice as many stations in this region reporting twice daily to the Central Office during the hurricane season, June 1 to November 30. The shipping using the Panama Canal will be most benefitted. During and for a few years after the Spanish-American War, the Weather Bureau maintained a service almost as extensive as now planned.

"$10,000 is to be used for more complete organization of the weather observation work in Alaska. Juneau is to become a regular Weather Bureau station and climatological section center. Not only will the climate of Alaska become more fully known, but also it is thought that the general weather and storm forecasts for the United States will be helped.

"Another $10,000 is to be used in extending the river and flood and the frost-warning services.

"The Weather Bureau has recently announced a new civil service examination designed principally for college graduates who are competent to carry on scientific investigation. The initial salary is $1,260 a year."

The Argentine Meteorological Office.—Word comes from Argentina that the Meteorological Office, first organized by Dr. B. A. Gould in 1872, and continued by Mr. W. G. Davis, 1884-1915, is being further developed by Mr. George O. Wiggin, who was Assistant Chief for many years. The service depends upon the Government Telegraphs, and the voluntary observations of patriotic citizens, supplemented by the post office and railroad employees, so that while the Republic is covered in about the same proportion as the United States, the cost to the nation hardly reaches the third part relatively to that paid by the Weather Bureau. It is proposed to reduce the number of volunteer stations, and train the observers at the remainder as paid computers and observers, as fast as practicable, so as to increase their efficiency and promptness for the forecast division. Professor F. H. Bigelow, who was connected with the United States Weather Bureau until 1910, has been placed in charge of the Pilar Solar and Magnetic Observatory, located about 20 miles south of Cordoba, together with the dependent stations at the South Orkney Islands near the Antarctic Continent in the midst of the ice, and at La Quiaca on the Bolivian Plateau about 12,000 feet above the sea level. Preliminary measures have

been taken to open a higher station at La Confianza, or at The Franco Aramayo Mine, about 15,000 feet above the sea level. These high stations have the same altitude as Mt. Whitney in the United States, but they can be operated throughout the year in the prevailing mild climate. Professor Bigelow's researches on the thermodynamics of the earth's atmosphere have been extended to seven gases on the sun, from hydrogen at one extreme to mercury vapor at the other, with the important result of obtaining the laws that govern the distribution of the temperatures, pressures, densities, gas efficiency in the solar envelope, as well as the temperature and source of the radiation. The latter seems to originate in a strange radioactive impulse at a temperature which would yield a little less than 6.00 gram calories per square centimeter per minute at the distance of the earth before depletions occur.

Spectral Evidence of a Persistent Aurora.—In photometric studies of the night sky illumination some observers have found an outstanding factor which would be accounted for if a permanent aurora be assumed to exist. Although photometrically difficult to decide, the problem lends itself readily to direct spectrographic analysis. The spectrum of the aurora consists of certain emissions of which one in the yellow-green is so intense relatively as to contain a considerable portion of the total auroral light. This line is therefore a sensitive test of the presence of auroral light. In consequence of this spectral concentration it is possible to record this characteristic auroral line with an exposure of only a few hours. Moreover, these spectral observations can be secured regardless of the presence of moonlight.

The spectrograph used in this investigation has a 66° flint glass prism and a commercial Dallmeyer lens of F 1.9 ratio as camera objective and thus is fairly well suited to the problem. Cramer Isochromatic plates were employed because of their high sensitiveness to the green of the spectrum and their ability to record the strong auroral line.

Since June, 1915, exposures have been made with this instrument sometimes nightly during last winter, this summer only at intervals. In some cases a small objective was placed in front of the spectrograph, more often the spectrograph alone was pointed to the sky. Upwards of fifty plates have been secured, with the spectrograph directed at different parts of the sky. All the exposures show the characteristic auroral line, and thereby the existence of auroral illumination persistent or permanent at least for the period covered by this series of plates.

The observations suggest that the auroral light is more intense toward the horizon and possibly toward the sunrise and sunset points of the sky. These and various questions such as the constancy of the light, its dependence upon sunspot activity, etc., call for considerably more extensive observations than those here described. What was attempted was merely to ascertain whether there exists a persistent or permanent illuminatton of the night sky by the aurora.

Plate I (Figure 1 Plate XI) shows the auroral line crossed by the comparison spectrum of V-Fe spark, made on a moonless night. Plate II (Figure 2 Plate XI) is from a plate made on a moonlight night and has the auroral line superposed upon the spectrum of moonlight.

Lowell Observatory, Bulletin No. 76. November, 1916. V. M. SLIPHER.

Request for Copies of No. 48 of the Publications of the Astronomical Society of the Pacific.—No. 48 of the *Publications of the Astronomical Society of the Pacific* is now out of print. In order to be able to fill occasional orders for complete sets, the Publication Committee desires to obtain a few copies of this number, in good condition, for which fifty cents will be paid.

Copies may be sent to H. D. Curtis, Mt. Hamilton, Calif.

PLATE XI

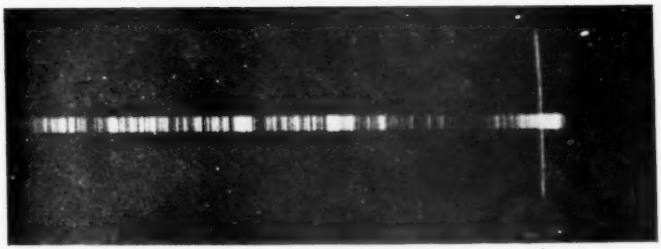


Fig. 1.

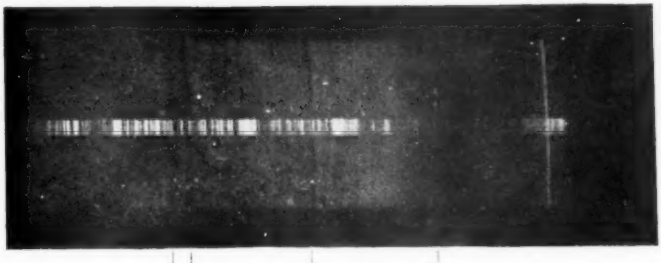


Fig. 2.

Aurora Spectrum Photographed at the Lowell Observatory, Flagstaff, Arizona.

Detroit Observatory Publications.—Volume II, of the Publications of Detroit Observatory, University of Michigan, Ann Arbor, Michigan, has just come to hand. It is a splendidly printed volume of 186 pages, illustrated with a number of most excellent plates. Director William J. Hussey says in the preface:

"In planning the reorganization of this Observatory in 1905, one of the objects sought was to provide means for modern astrophysical investigations. To this end a large reflecting telescope of the Cassegrain form, having an aperture of 37½ inches and an equivalent focal length of sixty feet, was designed and constructed at the Observatory under my supervision, the optical parts having been obtained from the John A. Brashear Company of Pittsburgh. This instrument was completed in May 1911, and since then it has been used almost exclusively for photographing stellar spectra with a single prism spectrograph. . . . . More than thirty-seven hundred spectrograms have now been made, and with few exceptions they are suitable for exact measurement. Nearly all of the papers of the present volume are based upon data obtained from a small proportion of these spectrograms, that is, from those which have already been measured and discussed. Other investigations are in progress."

The papers included in this volume are all of a high order of excellence. We have not space to give adequate reviews of them and so will be content with the briefest mention of the titles and some of the conclusions.

Dr. R. H. Curtiss, under the title "Studies of Class B Stellar Spectra containing Emission Lines" discusses the spectra of γ Cassiopeiae, f^1 Cygni and H. R. 985. He finds for γ Cassiopeiae, from the Ann Arbor spectrograms, a radial velocity of -6.4 ± 0.6 km, with no established periodic variations in velocity. The final velocity based on all known measures is -6.2 km. For f^1 Cygni he finds a progressive variation in the character of the lines, the fading out of the emission lines and intensification of the dark hydrogen lines, together with a change in their wave-length. If the change in wave-length is due to velocity, the range of velocity shown is about 60 km. For H. R. 985 also he finds a decided change in the wave-lengths of the hydrogen lines between 1912 and 1916, the mean velocity for the 1912 series of plates being -3.1 km, that for the 1916 series being $+41.7$ km. The K line was narrow and apparently fixed, yielding a mean velocity for the entire series of -9 km.

Dr. Paul W. Merrill gives an investigation of spectroscopic observations of 43 stars of Class Md. Concerning these he says:

"Eighty-five per cent of all the long-period variables are red stars whose spectra are characterized by absorption bands of titanium oxide and also contain bright hydrogen lines. Spectra of this kind are comprised in Secchi's third type, or are of Class Md in the Harvard system. Every star known to belong to this spectral class is without exception a variable of long or irregular period. The fact that such a spectrum always indicates this type of variability is a remarkable one which has never received a satisfactory explanation."

The range of velocities found for these stars is high, from -186 to $+101$ km or, when corrected for the sun's motion, from -166 to $+95$ km; and their average velocity comes out about 32 km, making them apparently the swiftest of any class of stars so far investigated. There is also some indication of systematic motion in the general direction of the solar ant-apex. None of these stars shows evidence of variation in radial velocity, so that their light variations cannot be explained as produced by eclipsing bodies revolving around each other. As a tentative explanation Dr. Merrill offers that of a cloud screen,

" . . . . it might be well to keep in mind the possibility that a star of this class may not actually change in brightness so greatly, but that at the time of minimum a screen is interposed between it and the earth, presumably in the immediate vicinity of the star. It is suggested that this might be composed of condensing gases, possibly calcium vapor, in the upper atmosphere of the star. Calcium exists

at high levels in the solar, and in many stellar atmospheres, and especially in these stars if we admit that the hydrogen line Hϵ is blotted from the spectrum by the absorption of calcium H. The cloud formed by condensation would conserve the heat radiated from the photosphere to space, so that the temperature of the materials immediately above the photosphere would increase until the overlying veil is again vaporized and the star shines out brightly. It is easy to conceive that these phenomena would be periodic and would cause variations in the spectrum, particularly in the atmosphereic emission."

Dr. Merrill also discusses the spectrum of the star DM. $+11^\circ$ 4673, which is of the P Cygni type. He finds this star to be intermediate between P Cygni and the wellknown bright-line stars of Class B. The bright hydrogen lines agree in giving a radial velocity of $+16.0$ km, while the bright lines of metallic origin give a velocity about 40 km less. The few weak absorption lines give a velocity of -13 km.

Three dissertations submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy in the University of Michigan are as follows:

"A Study of the Spectrum of ζ_1 Ursae Majoris," by Lawrence Hadley.

"An Investigation of the Spectra of Stars belonging to Class R of the Draper Classification," by W. Carl Rufus.

"A Study of Beta Cephei," by Clifford C. Crump.

Mr. Bernhard H. Dawson gives a study of the spectrum and radial velocity of ρ Leonis.

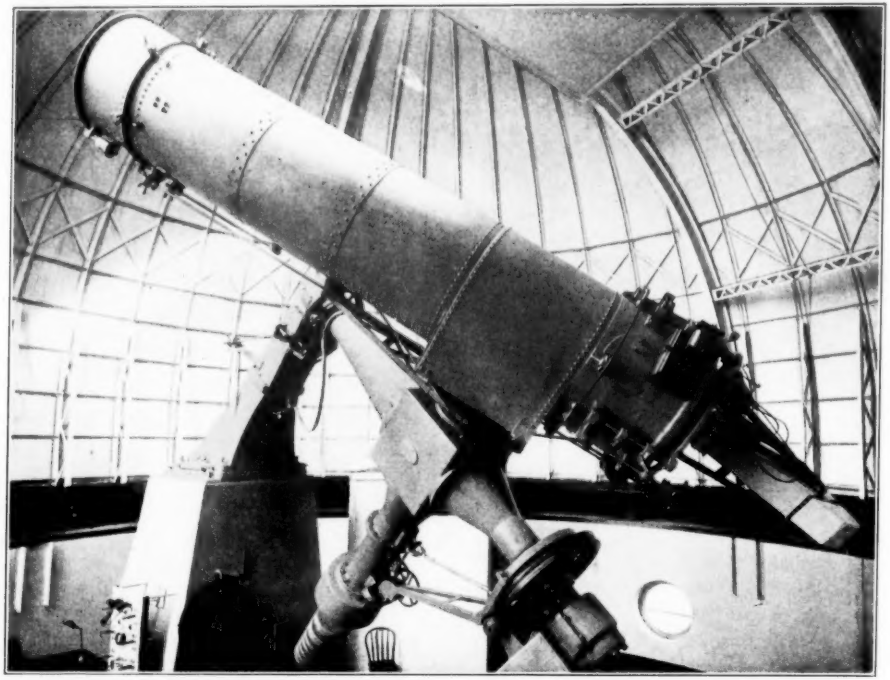
All these papers are full of matter which is of the highest interest to those who know even a very little of the principles of spectrum analysis and the methods of determining the radial velocities of stars.

The Greatest Need of Astronomy.—The Report of the Subcommittee on Astronomy, of the "Committee of One Hundred on Scientific Research" of the American Association for the Advancement of Science, published in the February 9 number of *Science*, states that the greatest need of astronomy appears to be "a large fund whose income could be used in" certain ways which are specified by the Committee. We give below the entire report:

REPORT OF THE SUBCOMMITTEE ON ASTRONOMY.—The science of astronomy differs in a marked manner from many other departments of human knowledge. Owing to the large sums of money which have been given to it, extensive organizations have been effected, thus enabling astronomers to undertake the great routine investigations which at present are regarded as the most important objects of astronomical research. No one will doubt that in this, as in every other science, the advance depends largely on individual genius and initiative. The invention of new methods has, however, now been so far accomplished that many astronomers are able to devote their time to applying these methods to large numbers of individual stars. Investigations which require years of continuous effort, and an expenditure of many thousands of dollars may thus be undertaken and successfully completed. The application of the methods of scientific management has effected the same saving as in industrial processes. An excellent example of this is the determination of the accurate positions of one hundred thousand northern stars. This work, begun half a century ago, was divided among a dozen observatories, and was probably the most important astronomical research undertaken up to that time. One zone occupied an observer and corps of assistants for twenty years. The salaries alone exceeded one hundred thousand dollars. By the aid of photography this work is now being repeated with double the accuracy, and at less than a tenth of the cost. In another investigation, a saving of one minute in the reduction of an observation will reduce the time of its preparation by two years of the work of one assistant.

The greatest need of astronomy appears to be a large fund whose income could be used in the following ways:

1. Reestablishing the friendly international relations of astronomers of three years ago by assisting large astronomical projects directly or indirectly. Such projects can often be carried out far better and more economically by dividing the work between two or more observatories. The Cape Photographic Durchmusterung is a striking example of the excellent results of such cooperation.



THE THIRTY-SEVEN INCH REFLECTOR AND SPECTROGRAPH OF THE DETROIT OBSERVATORY, UNIVERSITY OF MICHIGAN, ANN ARBOR, MICH.

2. Furnishing assistants to astronomers who would thus be relieved of laborious routine observations and computations. An excellent illustration of this was the article in *Science*, Vol. 41, 82, giving the replies of twelve leading astronomers regarding their greatest need. In almost every case it was one or more assistants.

3. Aiding observatories south of the equator in such a way as to render our knowledge of the southern stars more nearly equal to that of the northern stars. At present, many times as many observations are made of northern, as of southern, stars.

4. Providing means whereby preliminary investigations, sufficient to decide upon the best and most efficient methods of carrying on large projects, can in all cases be undertaken before these projects themselves are entered upon.

5. Establishing bureaus, generally at existing institutions, at which certain lines of investigation could be carried on for any astronomers needing them. For example, a computing bureau which would prepare the tables needed for any special or general purpose, as a bureau for computing orbits of newly discovered asteroids, or comets, a bureau for measuring photographs, thus determining precise positions, radial velocities from spectra, etc. Such work can be carried on far more efficiently by an astronomer in his own surroundings than if he is transported to a new establishment.

6. Making arrangements by which astronomers, overburdened by teaching, would be enabled to devote a specified portion of their time to research.

7. Assisting students taking postgraduate courses in astronomy, so that they could continue such work.

8. Supplying small telescopes, or other appliances, to those qualified to use them.

9. In general, aiding the advance of astronomy in any way that might prove efficient.

E. C. PICKERING, *Chairman*.
ERNEST W. BROWN,
WILLIAM W. CAMPBELL,
EDWIN B. FROST,
HENRY N. RUSSELL,
FRANK SCHLESINGER.

"Astronomy and the End of the War."*—Under this head was published in the March number of the "Revue du Ciel" the following article, contributed by a subscriber to that periodical:

"In reading the *Corriere della Sera* I notice a prophecy relative to the duration of the present war and which has to do with the beautiful science of Astronomy. It is the Chevalier Monti, director of the Civic Museum at Como who possesses the text of it, or at least the copy from a manuscript of the XVII century. The *Revue du Touring-Club* of Italy has furnished, it seems, a photographic fac-simile of this curious bit, whose author is no other than he to whom is attributed the famous prediction called that of Saint Malachi, who under the form of symbolic devices and emblems has characterised the reign of different Popes.

"Although it is demonstrated today that the prophet in question lived in the fifteenth or sixteenth century, whereas Saint Malachi died in the middle of the twelfth, the two predictions are none the less interesting. Here is the translation of the passage relative to the present war:

"'When the first number shall meet the ninth and when they two shall be united with the first and the sixth (1916), during the sixth month of the year (August according to the old calendar) and after two times four and two times ten days shall have passed (August 28), the new races which draw their name from Romulus (Roumania) shall rise and shall ally themselves with powerful nations. Then the fierce beast who for two years and one month (exact date of the beginning of the war) has been filling all the earth with blood, with horror, and with carnage, now surrounded, smitten from all sides and roaring in vain, will seek whom he may devour but shall not find him. There shall be new battles while new moons shall wax and wane thirteen times. The fifth day after the sun leaves the sign of the Lion, the beast shall die of a fearful death. A virgin whose name contains two iotas, two alphas, a tau and a lambda (Italia) shall crush his head and the latin peoples shall share his spoils.'

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* Translated from the French by Professor J. P. Bird, Carleton College.

"A good half of the prediction, remarks the *Corriere della Sera* is already accomplished; we shall see if the remainder will conform to the beginning.

"Let us leave to the astronomers the task of clearing up the computation of the moons.

"It seems at first sight that the problem does not exceed my astronomical knowledge; it is for that reason that I take the liberty of sending you the reflections which this prophecy has inspired in me.

"The twenty-eighth of August 1916 was new moon, and the thirteenth thereafter falls on August 17, 1917. So when thirteen new moons have set, we shall be at the seventeenth of August of this year. The war would end then in the moon which extends from the seventeenth of August to the sixteenth of September 1917. At what date? That point the second part of the prophecy determines.

"The sun this year leaves the sign of the Lion on August 23; the fifth day thereafter brings us to the 28th of the same month. That is, according to the author, the day which is to mark the end of the war and it is at least curious to note that a scholar living three or four centuries ago, has been able thus to determine the two astronomical circumstances. Events will tell us whether the prophet was right and whether really the present war will come to an end on the twenty-eight of August of this year."

WITH THE ROLLING YEARS.

"Constant as Earth is to Polaris' light,"
We say, as synonym for steadfastness,—
Forgetting that in the dim ages past,
Not the clear star that gems the Lesser Bear,
But Thuban of old Draco's misty coils,
Was the pale star to which the mariner
Turned seeking eyes, and steered him calmly on.
Thousands of years Polaris guides our way,
And yet in thousands more we shall have left
His light behind, and then fair Deneb's gleam—
That golden nail that marks the Cross's head—
The Earth shall know its pole-star, and shall raise
Its eyes unto the sign once lifted up.
Age upon age shall pass, and if our world
Still swings in its old orbit mid the stars,
Shall Vega, flashing from the silver Lyre,
Blue-white and glorious, a newer light,
Guide through the deep the voyager to his home.
But while the Earth whirls on through time and space
Man's eyes shall look to heaven and find his star.

God, the immutable, is changing too—
Within his children's hearts. No Moloch grim
Holds out his bloody hands for sacrifice,
Nor for dumb Apis is the golden cup,
Tossed every year into the swelling Nile,
Nor Saturn's power, nor Jove's, is longer feared;
And even the God of Sinai's awful mount,
Who spake from out the thunder and the cloud,
Calls but today in tones of father-love.
But while there is a world there shall be still
A God to whom its children lift their eyes.
We leave behind the Monster and the Brute
As type of God-head; and the dream of Might,
Which even yet sways the blind minds of men,
Shall also pass, and towards that far white star
Of light and love and human brotherhood
Our hearts shall turn,—even as our planet hears,
And sweeps to near, the music of the Lyre.

Brooklyn, N. Y. —FRANCES ISABEL BEERS.